Trumpeter Swan (*Cygnus buccinator*): A Technical Conservation Assessment

Prepared for the USDA Forest Service,
Rocky Mountain Region,
Species Conservation Project

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COVER PPOTO CREDIT

Photos of the trumpeter swan (*Cygnus buccinator*). Photographs by Arnie Fredrickson, life member of the Trumpeter Swan Society. Used with permission.

Summary of Key Components for Conservation of The Trumpeter Swan

The trumpeter swan (*Cygnus buccinator*) is classified as G4 (apparently secure) by the Natural Heritage Program because of its wide distribution across North America and its increasing population trends. In 2005, the North American population was estimated to contain 34,803 individuals. Abundant and widespread across most of North America prior to the 19th century, the trumpeter swan was nearly extirpated in the contiguous United States due to market-hunting. In response to range-wide conservation efforts, including protection from hunting, reintroductions, land acquisition, and wetland management, the three regionally-managed populations (Pacific, Rocky Mountain, Interior) have increased at a rate greater than 5 percent per year since range-wide surveys were implemented in 1968. Only the breeding flock in the Greater Yellowstone region has not increased; there, flock size has remained stable since 1968. The only flock that occurs within the USDA Forest Service's (USFS) Rocky Mountain Region (Region 2) is the High Plains flock (formerly Lacreek), which was originally established in the Lacreek National Wildlife Refuge, South Dakota in the early 1960's via reintroduction. This flock has expanded into western South Dakota, eastern Wyoming, and western Nebraska, has increased at a significant rate of 4.9 percent per year from 1968 to 2005, and currently numbers around 500 individuals.

The trumpeter swan is afforded a significant amount of attention by government agencies, private organizations, and individuals because of its striking plumage, large size, and iconic status. Management is directed by a national waterfowl management plan and three regional trumpeter swan management plans. On-the-ground management is typically conducted on a flock-by-flock basis.

In Region 2, the most significant threat to trumpeter swans appears to be the lack of migration by the High Plains flock to locales south of 40 degrees latitude where climatic conditions are favorable for overwintering. Additional threats to trumpeter swans include lead poisoning, hunting, and human disturbance. Conservation in Region 2 should focus on protecting, restoring, and creating wetland habitats, both for wintering and breeding swans.

The greatest opportunity for USFS Region 2 to contribute to swan conservation may be to encourage the expansion of breeding swans into central and eastern Wyoming. Swan establishment in this area may create a link between the High Plains flock in Region 2 and the Tri-state breeding flock just outside of Region 2, contributing to long term viability of both flocks. However, any action to expand the breeding range needs to be paired with equal efforts to provide wintering habitat within or south of Region 2. Important factors to consider when identifying sites for management are whether the site is free of lead, has a low level of human disturbance (including hunting), and has adequate food resources. Wetland management needs to integrate the dynamic nature of wetlands, including annual water-level fluctuations following wet/dry climate cycles. Non-fluctuating water levels are critical during the nesting period to swans; however, occasional wetland drawdowns are necessary to maintain wetland function and biodiversity, and to maintain the long-term productivity of nesting swans.

Although management efforts may be most easily conducted on public lands, conservation directed towards private lands must be emphasized, given the fact that over 70 percent of lands within the Great Plains are privately-owned. There are an increasing number of opportunities to develop public-private partnerships to both restore and create wetland habitat suitable for trumpeter swans through innovative conservation funding programs, such as the Wetland Reserve Program, the U.S. Fish and Wildlife Service's Joint Venture Program, and North American Wetlands Conservation Act.

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INTRODUCTION

This conservation assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2), USDA Forest Service (USFS). The trumpeter swan is the focus of an assessment because it is listed as a sensitive species by Region 2 (**Figure 1**). Within the National Forest System, a sensitive species is a plant or animal whose population viability has been identified as a concern by a regional forester because of significant current or predicted downward trends in abundance or habitat capability that would reduce a species distribution (FSM 2670.5 (19)). Because a sensitive species may require special management, knowledge of its biology and ecology is critical. This assessment addresses the biology and ecology of the trumpeter swan throughout its range in Region 2. This introduction describes the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

Species conservation assessments produced for the Species Conservation Project are designed to provide land managers, biologists, government agencies, and the public with a thorough discussion of the biology, ecology, conservation status, and management of select species based on current scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. This assessment does not seek to develop prescriptive management. Instead, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). The assessment does discuss management strategies in place for the species, as well as recommendations proposed elsewhere. When such management

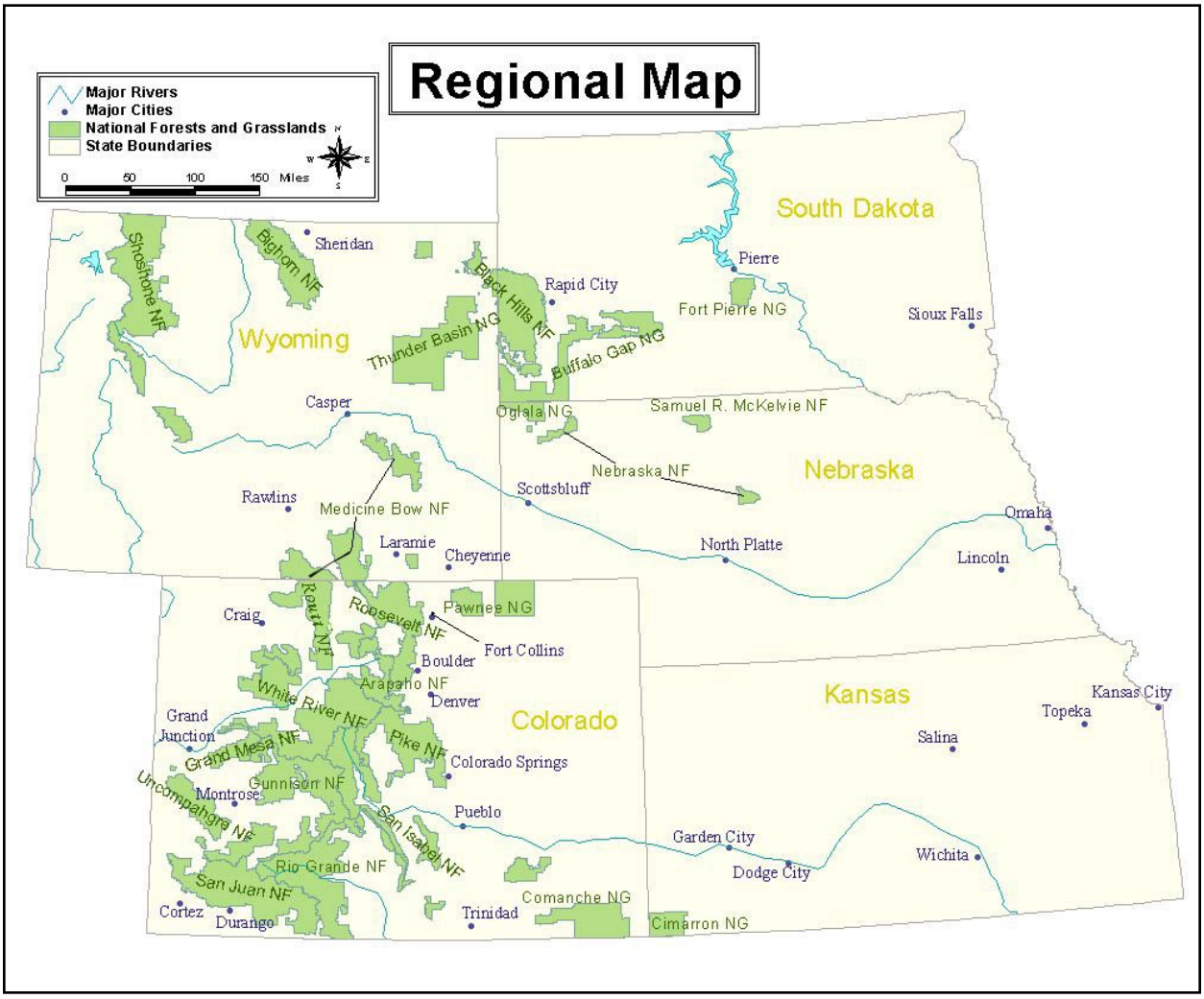

Figure 1. Regional map of USDA Forest Service Region 2. National forests and grasslands are shaded in green.

recommendations have been implemented, the results of the implementation are described.

Scope

The trumpeter swan conservation assessment examines the biology, ecology, conservation, and management of this species with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although most of the literature on the species originates from field investigation outside the region, this document works to place that literature in the ecological and social context of the central Rocky Mountains and western Great Plains. Similarly, this assessment is concerned with characteristics of the trumpeter swan in the context of the current environment. The evolutionary environment of the species is considered in conducting the syntheses, but placed in a current context.

In producing the assessment, I reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on trumpeter swans are referenced in the assessment, nor were all published materials considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications or reports were regarded with greater skepticism, but they were used when refereed information was unavailable.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and observations limited, science focuses on approaches for dealing with uncertainty. Sorting among alternatives may be accomplished using a variety of scientific tools (experiments, modeling, logical inference). In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are accepted as sound approaches to understanding and used in synthesis for this assessment.

Publication of Assessment on the World Wide Web

To facilitate use of the species conservation assessments, they are being published on the Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists and managers and the public more rapidly than publishing them as reports. Moreover, Web publication facilitates their revision, which will be accomplished based on procedures established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This report was reviewed through a process administered by the Society for Conservation Biology, employing at least two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGMENT STATUS AND NATURAL HISTORY

Management Status

In 2000, the Tri-state breeding flock, the United States breeding segment of the Rocky Mountain population that breeds in the greater Yellowstone ecosystem, was petitioned for protection under the Endangered Species Act as a discrete population segment. However, in its 12-month finding, the U.S. Fish and Wildlife Service (USFWS) found that protection was not warranted (Federal Register 2003). In Wyoming, the species is listed as a species of concern because its population size and distribution are small and because of ongoing habitat loss. No other states within Region 2 have a special designation for the trumpeter swan.

The Natural Heritage Program's global conservation status rank for the trumpeter swan is G4 (apparently secure); likewise its rank within the United States and Canada is N4 (apparently secure) (NatureServe Explorer 2005). Conservation ranks vary among the states within Region 2, but within each state, ranks are identical for both breeding and nonbreeding populations. In Wyoming and Nebraska, the trumpeter

swan is ranked S2 (imperiled) because of its rarity and restricted range while in South Dakota it is ranked S3 (vulnerable). The Natural Heritage Program assigned a conservation status rank of SNA (non-applicable) for the trumpeter swan in Kansas and Colorado because it considers the species to not be a suitable target for conservation activities in those states (**Table 1**; NatureServe Explorer 2005).

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

No regulatory mechanisms or laws specifically target protection of the trumpeter swan. However, several laws exist that provide protection to a broad array of wildlife species that includes the trumpeter swan. These laws include the Migratory Bird Treaty Act of 1918, the National Forest Management Act of 1976, and the National Environmental Policy Act of 1969.

The Migratory Bird Treaty Act establishes a federal prohibition against the take of migratory birds (including the trumpeter swan), unless permitted by regulations. Take is defined as to "pursue, hunt, take, capture, kill, attempt to take, possess, offer for sale, sell, offer to purchase, purchase, export, at any time, or in any manner, any migratory bird, including any part, nest, or egg of any such bird" (16 U.S.C. 703). Under the National Forest Management Act, the USFS is required to sustain habitats that support healthy populations of all native and desired non-native plant and animal species on national forests and grasslands. The National Environmental Policy Act requires agencies to specify environmentally preferable alternatives in land use management planning. Additional laws with which USFS management plans must comply are the Endangered Species, Clean Water, Clean Air, Mineral Leasing, Federal Onshore Oil and Gas Leasing Reform, and Mining and Minerals Policy acts; all are potentially relevant to trumpeter swan conservation.

The North American Waterfowl Management Plan recognizes three regional trumpeter swan populations: Rocky Mountain, Interior, and Pacific Coast populations (**Figure 2**; North American Waterfowl Management Plan, Plan Committee 2004). Management plans for each population have been developed to provide broad direction to the USFWS, Canadian Wildlife Service, state and provincial agencies, and other organizations engaged in the cooperative management of these populations. Individual plans outline efforts to maintain or restore populations based on population management goals and objectives and discuss management concerns and the strategies to address them. Individual plans vary in their complexity, from being mostly conceptual to highly strategic. For example, the fully developed Rocky Mountain plan outlines seven objectives and sixty-seven tasks related to population management, public information, and research (Hemker 2004, Pacific

Table 1. Natural Heritage Program rankings for the trumpeter swan in North America and states within USDA Forest Service Region 2 (NatureServe Explorer 2005).

Nation/State	Natural Heritage Program Rank
Canada	N4B, N4N
United States	N4B, N4N
Wyoming	S2
South Dakota	S3B, S3N
Nebraska	S2
Kansas	SNA
Colorado	SNA

N4 Apparently secure at the national level - Uncommon but not rare, and usually widespread, although the species may be quite rare in parts of its range, especially at the periphery

S2 Imperiled – Vulnerable to extirpation, rarity due to restricted range, few populations, or steep declines.

S3 Vulnerable - Either because rare and uncommon, or found only in a restricted range (even if abundant at some locations).

S4 Apparently Secure - Uncommon but not rare, and usually widespread, although the species may be quite rare in parts of its range, especially at the periphery.

S5 Considered Secure - Common, widespread, and abundant; essentially ineradicable under present conditions.

SNA Not applicable – Assigned when the species is not a suitable target for conservation activities.

B Breeding population.

N Nonbreeding population.

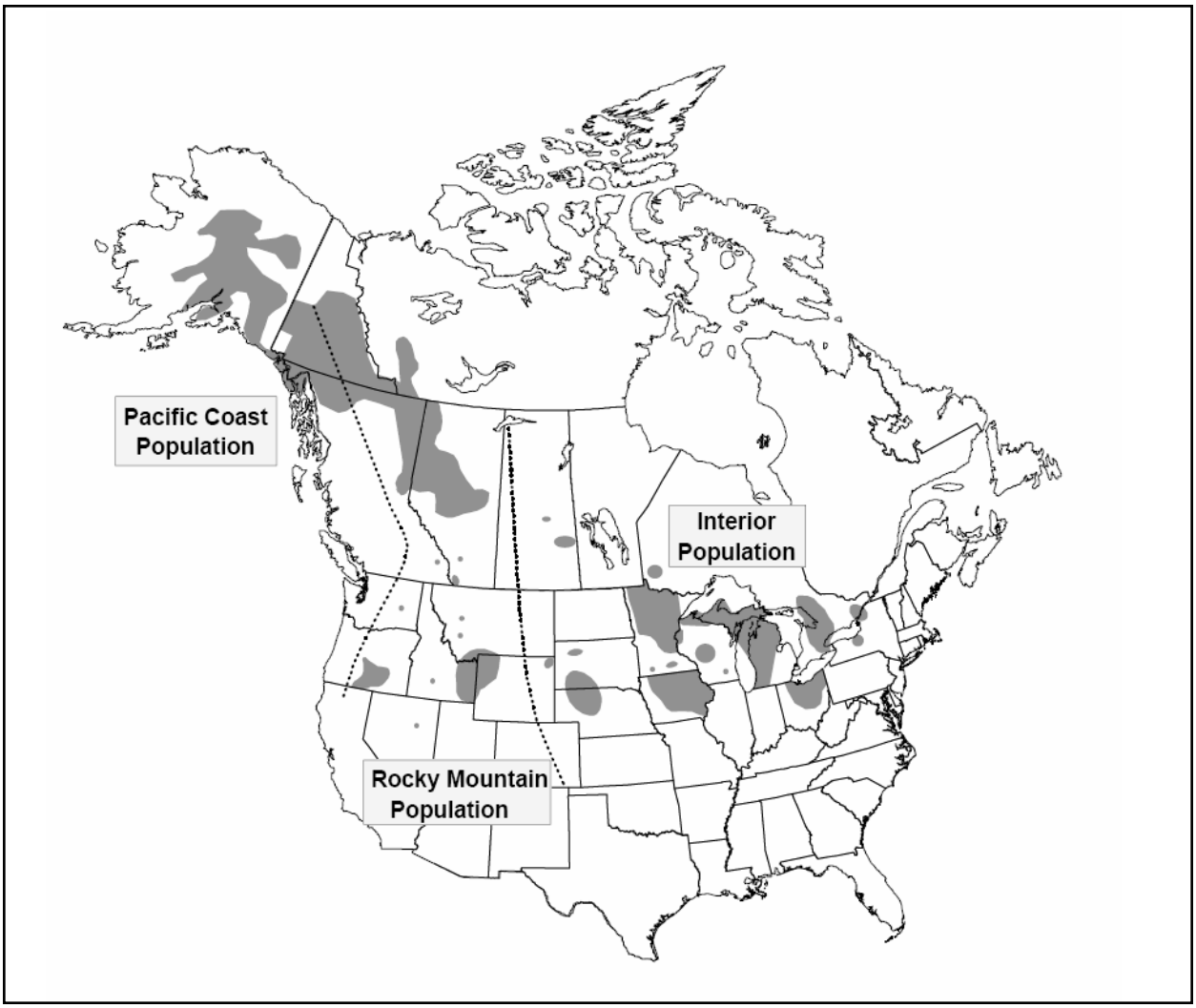

Figure 2. Approximate ranges of regional breeding populations of trumpeter swans (Caithamer 2001).

Flyway Study Committee 2004), while the Pacific Coast and Interior plans outline broader objectives. The primary goal of the Pacific Coast population management plan is to maintain the existing breeding and wintering distribution of swans and to allow populations to fluctuate naturally above a minimum population of 13,000 individuals (Subcommittee on Pacific Coast trumpeter swans 1993). For the Interior population management plan, the primary goal is "to restore a self-sustaining, migratory metapopulation of swans in the Central and Mississippi Flyways" (ADCIPTS 1998).

Biology and Ecology

Systematics and species description

The trumpeter swan is in the avian Order: Anseriformes, Family: Anatidae, and it is one of three swan species, all in the genus *Cygnus*, found in North America. It is the largest North American swan, with adults reaching a total length of 1.4 to1.6 m, wing spans of 2.0 to 2.4 m, and weights of 9.5 to 13.5 kg; males are slightly larger than females (Mitchell 1994, Sibley 2000). Age classes are distinguished by plumage characteristics and coloration of bill, tarsi, and feet, but sexes are monomorphic. Adults (> 2 years old) are entirely white but often have head and neck feathers that are stained a rust color from foraging in mud or iron-rich waters. Their tarsi and webbed feet are black, as is their bill except for a red border on the lower mandible (Banko 1960, Mitchell 1994). Second-year trumpeters are mostly white but retain some pale gray to brown feathers on head, neck, and body, and their tarsi and feet are yellowish-gray to dull black; their bill is entirely black (Banko and Schorger 1976). Finally, first-year birds, termed "cygnets", are dull gray at hatching, with slightly darker feathers dorsally than

ventrally. Their feet and tarsi are gray-pink. Their bills are gray-black distally, becoming dull pink proximally; bills turn black during their first winter. In the Tri-state area (Montana, Idaho, Wyoming), 1.8 to 13 percent of cygnets are leucistic with a pale gray wash (Banko 1960, Mitchell 1994).

Trumpeter swans may be difficult to differentiate from tundra swans in the field if both species are not present, but they can be are distinguished by vocal, physical, and behavioral characteristics. Trumpeter swans are best discriminated by voice, with trumpeter's having a resonant, loud, low-pitched bugle-like call, while tundra's vocalizations are high-pitched and often quavering. Trumpeter swans have a longer bill with a straight profile and pointed forehead, as opposed to the tundra's concave bill and rounded forehead (Mitchell 1994). Tundra swans also have yellow lores, but this physical characteristic is variable among individuals. Trumpeter swans frequently bob their head and neck up and down, often giving a variety of vocalizations. This activity becomes especially pronounced when birds are disturbed and just prior to taking flight. Tundra swans do not bob their head and have no pre-flight display.

Distribution and abundance

Historical distribution

From brief and scattered historical notes and other literary sources, Banko (1960) pieced together the historical distribution of trumpeter swans, and it appears that the trumpeter swan was geographically widespread and abundant across most of North America prior to the 19th century (**Figure 3**). However, because trumpeter swans disappeared from much of their historic range prior to the period when an interest in the natural history of wildlife species was developing, information from many areas of the trumpeter's breeding range is lacking. Thus, some uncertainty exists in our knowledge of historical swan distribution and abundance. The core of their former breeding range included shallow lake, marsh, and slough wetlands from Alaska east across western Canada to the Hudson Bay lowlands of Manitoba, Ontario, Quebec, and east to Nova Scotia, New Brunswick, and Newfoundland (Hansen et al. 1971, Alison 1975, Lumsden 1984, 1992). At the southern limit of their breeding range, which likely reached from central California across the United States to the Carolinas, populations appear to have been more localized and patchily distributed (Banko 1960, Mitchell 1994). Breeding habitats in the marshes of the Great Plains, which would include much of the area within today's boundaries of USFS Region 2, appear to have been of relatively small importance in supporting continental populations of trumpeter swans (Banko 1960). The former wintering range of trumpeter swans included southeastern Alaska down the Pacific coast to southern California, across southern United States through Texas and the Gulf coast to central Florida (Mitchell 1994, Matteson et al. 1995). The northern limit of their wintering range was constrained by access to ice-free waters.

Historical estimates of the size of trumpeter swan populations are lacking, but early accounts from naturalists and records of swan skin sales from trading companies indicate that this species was numerous. In 1709, John Lawson, the Surveyor General of North Carolina, reported that great flocks of trumpeters arrived in the winter and inhabited the freshwater rivers (Banko 1960). John Audubon also wrote about substantial numbers of wintering swans using habitats along the Mississippi River and its tributaries from Ohio to the Gulf of Mexico. The Hudson Bay Company sold thousands of trumpeter swan skins annually, particularly to the London Fur Market, during the late 1800's (Banko 1960). Swan feathers and skins were important commerce items and used for the manufacture of powder puffs, the adornment of women's headwear, and quill pens.

Human exploitation and persecution of trumpeter swans during the 1800's resulted in the extirpation of swan flocks over vast areas of its range (Banko 1960). By the late 1800's, populations were so low that trade in swan skins had become nearly nonexistent; for example, only 57 swan skins were sold by the Hudson Bay Company to London during the period from 1888-1897 (Banko 1960). In 1932, less than 100 swans remained within the contiguous United States, secluded in the remote high mountain valleys of Montana, Idaho, and Wyoming. Undocumented flocks of unknown size also occurred in uninhabited areas of Alaska and western Canada (Hansen et al. 1971).

In response to the trumpeter swan's precarious status, the United States government established the Red Rock Lakes National Wildlife Refuge (NWR) in Montana's Centennial Valley in 1935. With increased habitat protection and management in Red Rocks NWR and in adjacent Yellowstone National Park, populations increased in this region, and translocations to other NWR's were conducted. By the 1950's, the contiguous United States population had increased to more than 500 birds (Banko 1960).

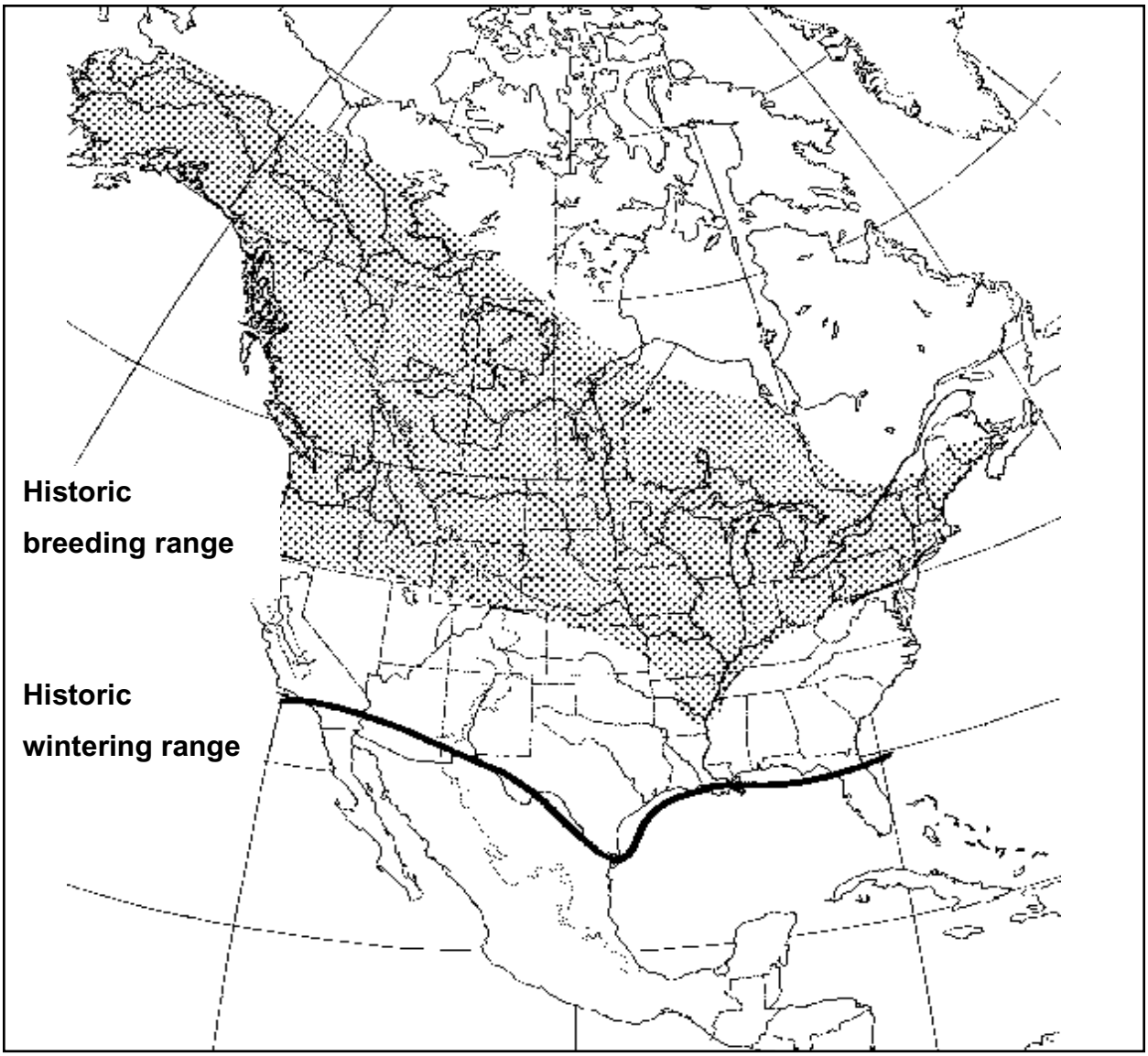

Figure 3. Historic breeding and wintering ranges of trumpeter swans (Matteson et al. 1995).

Current distribution

The USFWS recognizes three regional management group, based on the geographic areas in which they nest: Pacific Coast population, Rocky Mountain population, and Interior population (**Figure 2**; Mitchell 1994). Although termed populations, they were not delineated based on biological criteria such as reproductive isolation or genetic differences; rather they were loosely defined by flyways for management purposes (Trost et al. 2000). However, recent genetic analyses identified significant differentiation between the Pacific Coast and Rocky Mountain populations supporting current management designations (Oyler-McCance et al. 2006). Within each region, management is frequently directed toward subgroups or "flocks" of swans based on a variety of delineations including state and other administrative boundaries.

Trumpeter swans of the Pacific Coast population comprise 72 percent of the total individuals found in North America. Individuals from this population mainly breed in interior Alaska and coastal areas of south-central Alaska. Trumpeters nesting in western Yukon Territory and northwestern British Columbia are considered part of this population (Caithammer 2001). The Pacific Coast population is migratory and winters primarily in coastal and interior British Columbia, southeastern Alaska, and along the coast in Washington and northern Oregon (Subcommittee on Pacific Coast Trumpeter Swans 1993).

In the Rocky Mountain population, three subgroups, delineated by breeding areas, are generally recognized. These consist of the western Canada flock, which includes the Canadian breeding segment of the Rocky Mountain population; the Tri-state flock, which includes swans nesting in the Greater Yellowstone region of Idaho, Montana, and Wyoming (also referred to as the tri-state area or tri-state region); and the Restoration Area flocks, which includes reintroduced flocks in and around Malheur NWR and the Summer Lake area in Oregon and Ruby Lakes NWR in Nevada. The Canadian flock is the largest breeding segment of the Rocky Mountain population, totaling approximately 4,718 individuals (Moser 2006). Individuals from this flock breed in the central and eastern regions of the Yukon and Northwest Territories south to eastern British Columbia and Alberta, but migrate to the tri-state area for the winter. The Tri-state flock is nonmigratory, currently numbers around 450 individuals (Pacific Flyway Study Committee 2004), and is the only breeding population in the lower 48 states that avoided extirpation. The Restoration flocks in Oregon and Nevada were established through translocation of Tri-state flock individuals and are non-migratory. These flocks increased to 80 individuals in the 1990's, but they currently number around 50 individuals (Pacific Flyway Study Committee 2004).

Historically, it appears that the Interior population contained the greatest number of swans of all the regions, perhaps exceeding 100,000 individuals (Gillette and Shea 1995). Entirely extirpated by 1900, present flocks are the result of reintroduction efforts by government and private agencies using swans from both the Pacific Coast and Rocky Mountain populations. Established flocks occur in Minnesota, Michigan, Wisconsin, Iowa, Ohio, Ontario, Saskatchewan, and Manitoba. The High Plains flock (formerly the Lacreek flock), which was originally established in Lacreek NWR, South Dakota, has expanded into western South Dakota, eastern Wyoming, and western Nebraska, and constitutes the sole flock in USFS Region 2. In 2004, the High Plains flock numbered 534 individuals and was second in size to only the Minnesota flock, which numbers around 1,900 individuals (J. Johnson personal communication 2005).

Regional distribution and abundance

South Dakota: Trumpeter swans apparently bred in small numbers in the Sandhill lakes region of South Dakota and Nebraska prior to 1900, but were subsequently extirpated (Sharpe et al. 2001). They were reintroduced to South Dakota in Lacreek NWR during the period 1960-1962, and birds from these releases form the founder population for the High Plains flock (Monnie 1966). Fifty-seven cygnets were translocated from the Tri-state flock of the Rocky Mountain population, and the first breeding attempts occurred in 1964 (Monnie 1966). According to the South Dakota Breeding Bird Atlas, the trumpeter swan is considered uncommon with a limited range (Peterson 1995). The swan's breeding distribution is restricted to western South Dakota, including Harding, Perkins, Butte, Meade, Ziebach, Pennington, Haakon, Shannon, Jackson, Mellete, Bennett, Todd, and Tripp counties (Johnsgard 1979, Kraft 2004). During the nonbreeding season, swans often migrate back and forth from Lacreek NWR to the Nebraska Sandhills in response to ice conditions (Kraft 2004).

Nebraska: The trumpeter swan is considered rare during migration to locally uncommon and locally common during the breeding season and winter, respectively (Sharpe et al. 2001). The first breeding record for trumpeter swans in recent history occurred in 1968 in Sheridan County. Since then, trumpeter swans have expanded their breeding distribution into most parts of the Nebraska Sandhills, and the majority of these birds are resident (Sharpe et al. 2001). With the discontinuation of the winter feeding program at Lacreek NWR in the early 1990's, trumpeter swans began wintering in the Sandhill region (Kraft 2004). Trumpeters winter on the Snake River and North Loup River drainages in Cherry County, on Blue Creek in Garden County, along the North Platte River below the Lake McConaughy dam, and near Birdwood Creek in Lincoln and McPherson counties. Swans have also been recently reported in Grant County near Collins Lake (Kraft 2004). During spring and fall migration, there has been a recent increase in the number of swan sightings in eastern Nebraska, suggesting that some local migration is developing. In addition, some individuals are marked birds from other Interior population flocks in Minnesota and Iowa (Sharpe et al. 2001).

Wyoming: Within the boundaries of Region 2 (central and eastern Wyoming), the only location where trumpeter swans have bred since the establishment of the High Plains flock in 1960 is in Crook County near the town of Colony. However, swans have not bred there in recent years, and they were not detected in the 2004 late-summer survey (Comeau 2004). In general, few areas in central and eastern Wyoming appear suitable for trumpeter swans based on GAP analysis (**Figure 4**).

In western Wyoming outside of Region 2, swans breed in Yellowstone and Grand Teton national

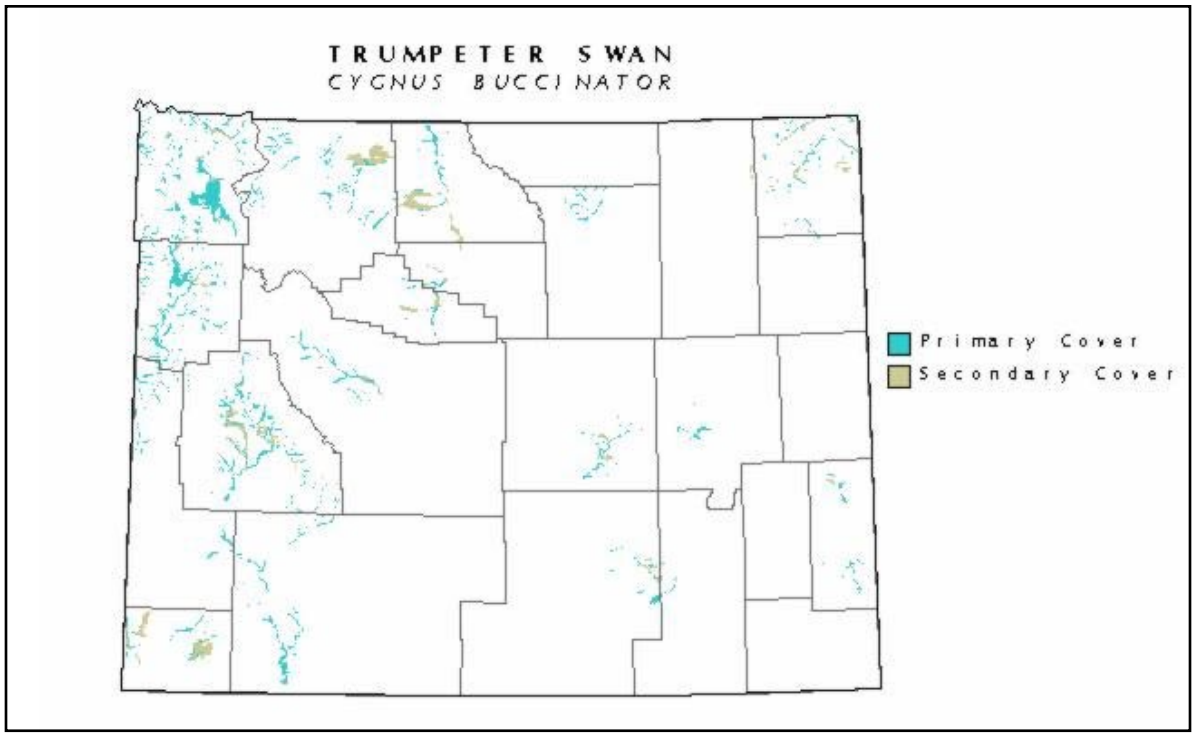

Figure 4. Map of predicted occurrences for the trumpeter swan in Wyoming based on GAP Analysis (Fertig and Beauvais 1999).

parks, near Jackson, and in the Salt and Green River drainages. Although adult numbers have changed little over the last decade, the breeding distribution has increased substantially due to reintroduction programs aimed at increasing the number of breeding swans in the Green River area and re-establishing swan migration routes down the Green River corridor to historic wintering grounds in southern Wyoming and areas farther south. During migration, trumpeter swans from both the Tri-state flock and the Canadian flock congregate in large groups at staging sites including Yellowstone Lake, Jackson Lake, the National Elk Refuge, and Fontenelle Reservoir.

Colorado and Kansas: Few records of swans have been reported for Colorado and Kansas. In Colorado, the trumpeter swan is considered a casual fall and early winter migrant on the eastern plains (Andrews and Righter 1992). According to GAP analysis, there appear to be few areas where suitable habitat exists for trumpeter swans in Colorado (**Figure 5**). A recent fall sighting of a swan on the South Platte River near Julesburg, Colorado and several sightings in northeastern and east-central Kansas indicate that migration patterns into these states may be developing (Kraft 2004), perhaps in response to increasing numbers in the High Plains and other Interior population flocks.

Regional discontinuities in distribution and degree of isolation

Although trumpeter swan breeding flocks in the Rocky Mountain and Interior populations appear as geographically discrete units, some flocks congregate on wintering grounds, and recent evidence suggests that these flocks are not genetically isolated. Oyler-McCance et al. (2006) found that the Tri-State and the Canadian breeding flocks of the Rocky Mountain population did not differ in genetic structure or genetic diversity, suggesting that interbreeding occurs between flocks. The two remaining United States breeding flocks of the Rocky Mountain population, the Oregon and Nevada Restoration flocks, also breed in isolation. However, both Restoration flocks are descended from Tri-state area swans. To date, banding data have not revealed movement between the Restoration flocks and either the Tri-State or Canadian breeding flock. In the central flyway, the High Plains flock, which is descended from the Tri-state flock and the only flock that occurs in Region 2, is geographically isolated from flocks in the Rocky Mountain population to the west and Interior population flocks to the east. The High Plains flock is comprised of a breeding group located in the traditional breeding area of South Dakota and Nebraska and a small but increasing breeding group in Saskatchewan. However, these groups winter together, and it is likely that genetic material is exchanged

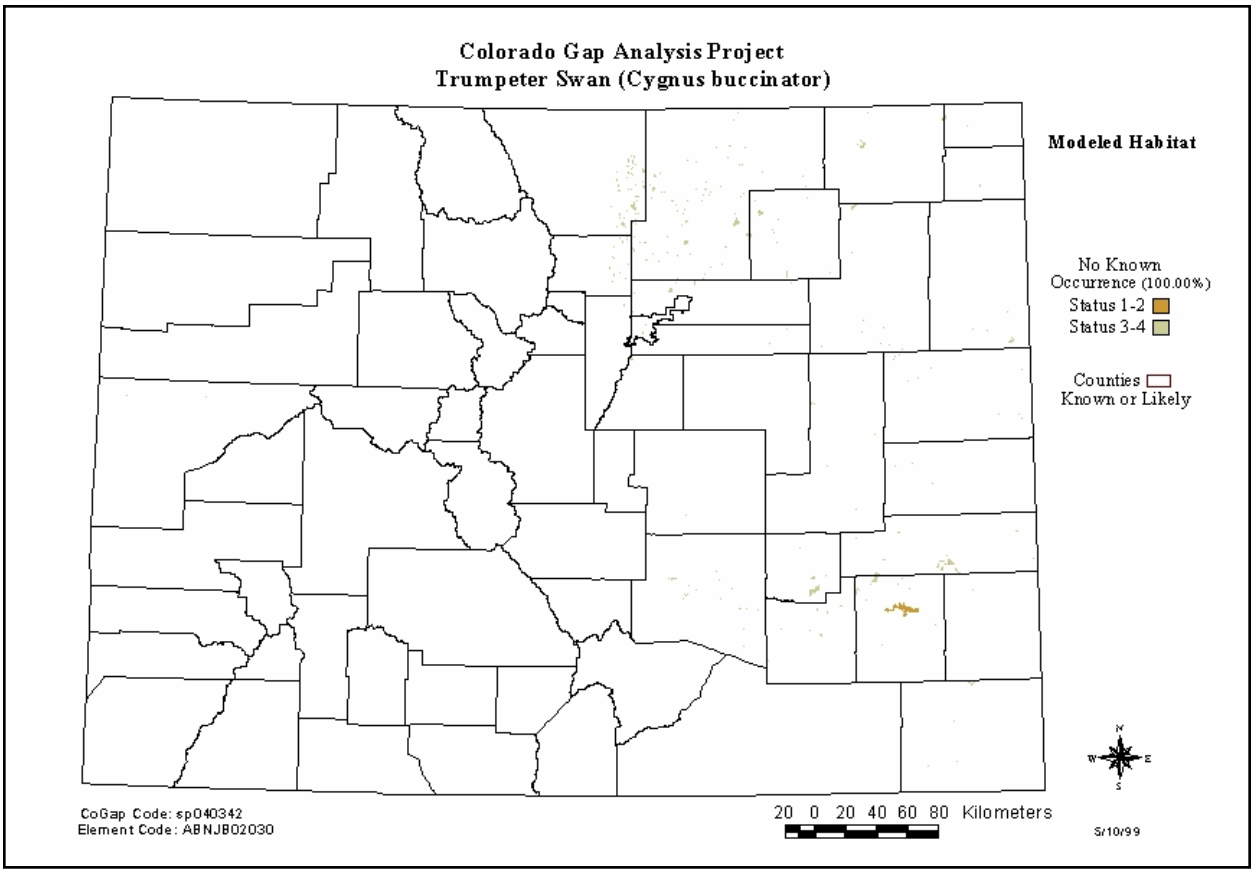

Figure 5. Modeled potential habitat for trumpeter swan in Colorado created by Colorado GAP Analysis Project.

between these two groups based on results from the Rocky Mountain population. Genetic analyses found no Pacific Coast population haplotypes in the High Plains flock, indicating that it is demographically isolated from other Interior flocks, which were all founded in part with Pacific Coast population individuals (Oyler-McCance 2006). Currently, the High Plains flock can be considered a closed population, and persistence depends on intrinsic demographic rates and not measures of emigration or immigration. If regional population trends remain at their current rate, swan distribution will likely continue to expand, increasing the probability of genetic interchange between flocks as the distance between discrete breeding flocks decreases.

Population trend

The trumpeter swan ranks as one of the best monitored species in North America, as their large size, white plumage, and specific habitat associations make them readily counted through a combination of aerial and ground-based surveys. Although many individual flocks are surveyed annually by local and regional organizations, both in the breeding and nonbreeding season, the only range-wide survey is conducted every 5 years in late summer, and results are summarized by the USFWS. The range-wide survey is a coordinated effort among numerous government agencies, private organizations, and individuals. Results are used to assess the status of the three regional populations. The first survey was conducted in 1968, followed by a survey in 1975, and then every 5 years afterwards, with the most recent survey conducted in 2005. Surveys are believed to be complete censuses except for northern British Columbia and the Yukon Territory, where population estimates are based on random samples across the suspected range of trumpeter swans. All population estimates are treated as though they were measured without error (Moser 2006).

In 2005, 34,803 swans were counted in North America (**Figure 6**). This represents an increase of roughly 47 percent from 2000, and an increase of 854 percent from the first survey in 1968 (Moser 2006). Over the entire survey period (1968-2005), the North American trumpeter swan population has increased significantly (P <0.001) at a rate of 6.0 percent per year (Moser 2006). Each regional population reached its greatest size in 2005, with the Pacific Coast population remaining numerically largest at 24,928,

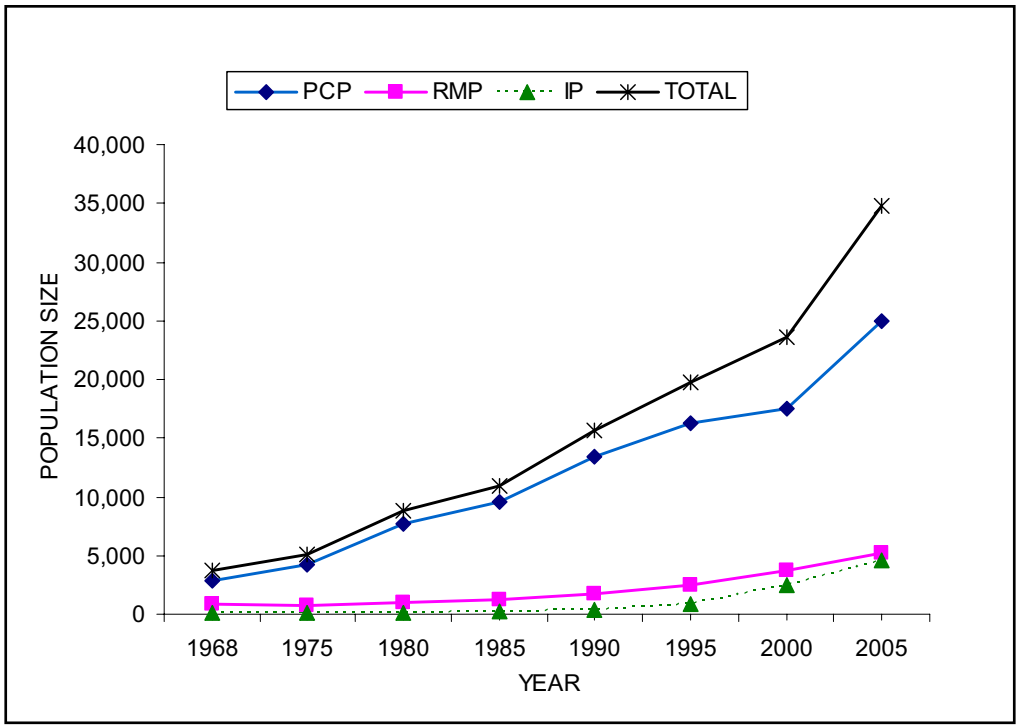

Figure 6. Population size and trends of total, Pacific Coast, Rocky Mountain, and Interior populations of trumpeter swans in North America (1968-2005). Data from Moser (2006).

followed by the Rocky Mountain population (5,228) and the Interior population (4,647) (Moser 2006). Each regional population of trumpeter swans has increased significantly over the survey period (1968-2000). The Pacific Coast population has increased significantly (P <0.001) at rate of 5.8 percent per year (Moser 2006). The Rocky Mountain population has increased significantly (P <0.001) at a rate of 5.4 percent per year (Moser 2006). However, this population increase is solely due to increases by the Canadian breeding segment of the Rocky Mountain population, as the flocks from the United States breeding segment have remained stable (the Tri-state flock; -0.8 percent per year) or declined (the Restoration flocks; -2.6 percent per year; P <0.05) (**Figure 7**). The largest annual increase in population size has occurred in the Interior population, which has increased significantly (P <0.001) at a rate of 11.7 percent per year (Moser 2006).

The sole flock occupying habitats within USFS Region 2 is the High Plains flock. This flock has increased at a significant (P <0.001) rate of 4.9 percent per year (Moser 2006). The U.S breeding segment of the High Plains flock has been monitored annually since 1980 by biologists at the Lacreek NWR through aerial surveys, and the population has exhibited a consistent increasing trend, supporting the range-wide survey data (**Figure 8**; data from ADCIPTS 2002, J. Johnson personal communication 2005).

Activity pattern and migration

Trumpeter swans vary their daily activity patterns in response to season, weather, gender, and reproductive status (Mitchell 1994). In response to cold winter temperatures, swans reduce feeding and increase sleeping activities; they increase their feeding rates during the day as temperatures increase (Squires and Anderson 1997). With the onset of spring, swans become hyperphagic, feeding at high rates during the day and night (Mitchell 1994, Squires and Anderson 1997). Presumably, this is to improve body condition for migration and breeding (Gale et al. 1987). In Wyoming, swans significantly increased proportion of time spent feeding from 30 percent in the winter to 45 percent in the spring (Squires and Anderson 1997). Information on daily activity patterns during migration is limited. At spring migration stopover areas in southern Alberta, swans foraged for 48 percent of the day, preened for 12 percent, rested for 19 percent, and were involved in locomotion 18 percent of the time (LaMontagne et al. 2001).

Apparently, long-distance migration by trumpeter swans has been greatly reduced due to the extensive shooting of migrants and the loss of migratory and wintering habitats (Gale et al. 1987). However, because most populations were extirpated prior to study, there is little empirical evidence to uncover historic migratory

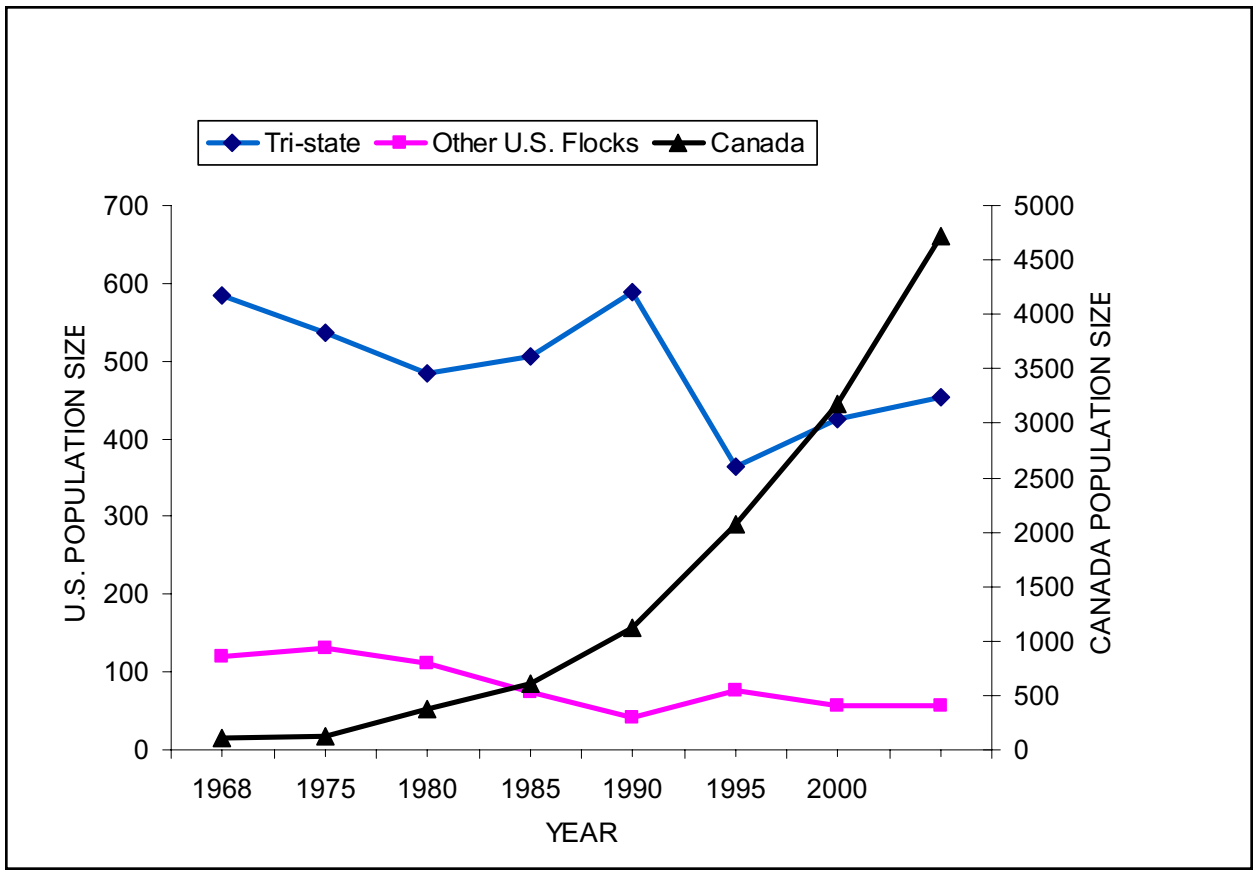

Figure 7. Population trends of United States (left axis) and Canada (right axis) breeding segments of the Rocky Mountain population of trumpeter swans (1968-2005). Data from Moser (2006).

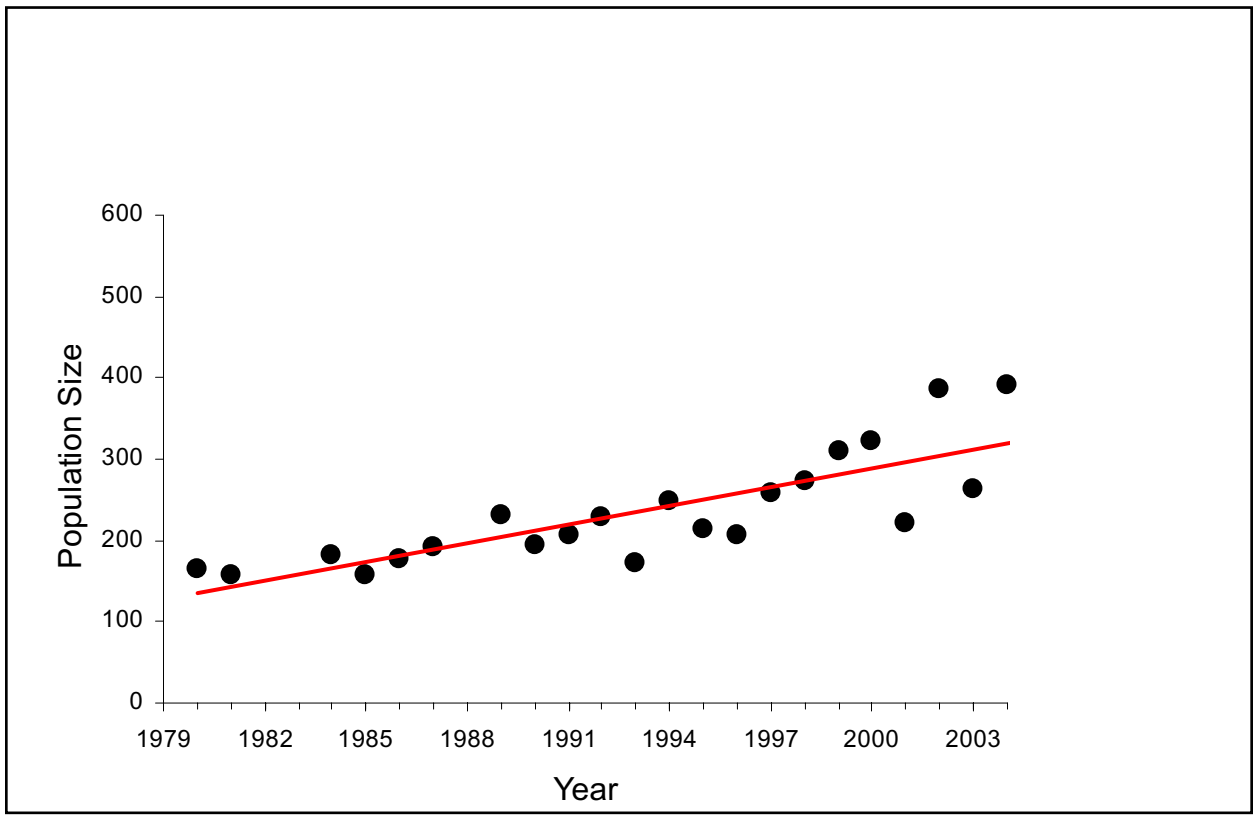

Figure 8. Population estimate and trendline for the High Plain flock of the Interior population from late summer survey of United States breeding segment.

pathways (Dubovsky and Cornely 2002). Within and among regional populations, flocks differ in their migratory pattern (Mitchell 1994). Most remnant flocks breeding in Alaska and western Canada migrate south to ice-free waters. In contrast, reintroduced flocks in all regional populations are relatively sedentary, exhibiting mostly local or short-distance movements in response to food availability and access to ice-free waters (Mitchell 1994).

Fall migration typically occurs in a stepwise process mediated by local conditions (e.g., ice and no forage). In general, trumpeter swans move from smaller sites to larger, ice-free waters. They are usually the last species to depart breeding areas, leaving in mid-October to late November as remaining patches of open water freeze-up (Mitchell 1994). Trumpeter swans of the Pacific Coast population migrate south by several routes to wintering grounds in southeastern coastal Alaska, coastal and interior of British Columbia, and coastal Washington (Mitchell 1994). The Canadian subpopulation of the Rocky Mountain population, breeding in the Yukon and Northwest Territories, British Columbia, and Alberta, migrates south, primarily east of the Rocky Mountains to the tri-state region (Mackay 1978). Many of these birds stage at Yellowstone Lake in Wyoming from late October to mid-November until the lake freezes over, at which time they move to other ice-free waters (Gale et al. 1987). Tri-state resident swans and reintroduced populations in Oregon and Nevada also make short-distance movements as wintering areas freeze and food is depleted (Mitchell 1994). Tri-state swans have occasionally moved to Utah, Arizona, and Colorado (Mitchell and Shandruk 1992).

Historically, most of the swans of the High Plains flock wintered in Lacreek NWR, where they were fed until 1992. Since then, swans have shifted their migration patterns, with most swans now wintering in the Nebraska Sandhills (Kraft 2004). In severe weather, birds may move farther south in Nebraska, and on into Kansas, Oklahoma, Arkansas, and Mississippi (Mitchell 1994). Other restored flocks of the Midwest exhibit variable migration patterns. In many of these flocks, populations are increasing rapidly and exhibit dynamic migration patterns.

Spring migration follows fall routes in reverse and is quite protracted. Trumpeters are one of the first birds to migrate to the breeding grounds, typically leaving winter sites in February and March (Mitchell 1994). Spring migration may be preceded by an increase in local movements to nearby thawing waters and open fields where food is available. Large lakes serve as important staging areas. Pacific Coast populations stage on large lakes near Whitehorse, Yukon Territory, while many Canadian swans of the Rocky Mountain population stage on Ennis Lake in Montana before migrating north. The protracted spring migration allows considerable time for foraging. Swans usually arrive on the breeding ground by April, often arriving before breeding lakes have completely thawed (Banko 1960).

Information on sex and age differences in dispersal capabilities and patterns is lacking. Swans migrate in small groups, often as family units, rather than in large flocks. Mean flock size of Alaskan swans on spring migration was 6.6 individuals per flock (King and Ritchie 1992), while mean flock size during fall migration was 10.6 individuals per flock (Cooper and Ritchie 1990). Nonbreeding swans and failed breeders leave the summer range earlier than successful breeders (King and Ritchie 1992). Delayed departure by breeders is due to the long period required to raise cygnets to an age capable of sustained flight (typically 145-150 days) (Hansen et al. 1971).

Habitat

Breeding

Based on fur-trade records, the open boreal forests of Alaska and Canada historically supported the greatest abundance of breeding swans (Banko 1960). However, as evidenced by their wide breeding distribution in North America, trumpeter swans breed in numerous ecosystems, inhabiting arctic-alpine, boreal forest, montane, pacific rainforest, aspen parkland, eastern deciduous forest, and grasslands regions (Banko 1960).

Landscape-scale habitat characteristics associated with trumpeter swan breeding and the growth and maintenance of trumpeter flocks have not been quantified. However, for a gregarious and large-bodied bird, one must assume that habitat attributes such as the quantity, type (e.g., depth, natural vs. manmade), and configuration of wetland habitats, and their proximity to human development (e.g., road density, power lines) are important.

At the local scale, trumpeter swans are restricted to shallow, freshwater marshes, ponds, lakes, and occasionally slow-moving rivers (Banko 1960, Hansen et al. 1971, Gale et al. 1987). Suitable wetlands can vary substantially in their physical (i.e., size, topography, elevation, hydrology) and biological (i.e., macrophyte and invertebrate communities, surrounding vegetation) characteristics, but several basic features are required:

- approximately 100m of unimpeded water for taking off for flight
- accessible forage (see Food Habits section)
- shallow, non-fluctuating levels of unpolluted water
- structural materials to build a nest platform, such as an island, a muskrat lodge, or emergent vegetation
- low human disturbance (Mitchell 1994).

During the nesting period, swans require non-fluctuating water levels to ensure nests do not flood during incubation and water levels persist until cygnets have fledged (R. Shea, personal communication 2006).

Anecdotal evidence suggests that habitat quality of swan breeding wetlands declines in the absence of periodic drawdowns (R. Shea, personal communication 2006). Drawdowns increase wetland productivity through the oxidation of the soil and the release of nutrients, providing favorable conditions for plant growth, including swan foods. Unmanipulated wetlands usually experience drawdowns through natural drought cycles. In wetlands with water control structures, however, managers can override natural wet/dry climate cycles and keep waters stable. Empirical evidence is lacking for the optimal periodicity of drawdowns for swans, but a general rule of thumb may be once every five to 15 years, depending on the locale's climate, elevation, and soils.

Migration and wintering habitat

Habitats used by swans during migration and wintering seasons are similar to those on the breeding grounds. However, access is often limited by ice, forage, and human disturbance. In general, migrating swans stage on larger marshes and lakes, but they may be forced to water bodies (e.g., rivers) where flowing water keeps ice from developing. From a landscape perspective, the availability of numerous wetlands of varying size and type appears to be important. This ensures that wetlands are available to swans in their stepwise movements along migration routes. It also increases the probability that ice-free waters will be available somewhere in their wintering area. Wintering birds from the Pacific Coast population often roost and feed in estuarine habitats and adjacent agricultural lands (McKelvey 1981, Anderson 1993). In the tri-state region, habitat use depends on food availability, open water and ice conditions, and the number of swans present (Snyder 1991). Most swans winter on rivers where flow reduces ice formation. Lockman et al. (1987) identified ten characteristics of ideal winter habitat in the tri-state region:

- 100 m of open water for take-off
- stream channel widths of at least 15 m
- water velocity under 45 cm per s
- little or no shrub cover on banks of water bodies
- suitable foraging depths (i.e., between 0.6 and 1.3 m)
- soft substrates greater than 5 cm deep
- abundant and diverse macrophyte assemblage
- greater than 75 percent open water and water freezing for less than two consecutive days
- water free of pollutants, especially lead
- little human disturbance.

Home range and territory size

There is no information on home range areas for trumpeter swans. Territory size varies from 1.5 to 100 ha and may depend on shoreline complexity and amount of available food resources (Hansen et al. 1971, Lockman et al. 1987, Mitchell 1994). Breeding trumpeter swans defend territories against conspecifics, but they may tolerate young from the previous year (Lockman et al. 1987, Mitchell 1994). However, in many cases, only one pair of swans is present on a pond. The intensity of territorial defense declines as cygnets leave the nest but may persist until the young fledge (Henson and Cooper 1992, Mitchell 1994). Non-breeding swans are social and gregarious, as are swans during migration and wintering periods (Mitchell 1994).

Food habits

Trumpeter swans feed primarily on the leaves, stems, roots, and tubers of submerged, floating, and emergent plants (Mitchell 1994). Cygnets initially feed on aquatic invertebrates, but they shift to an herbivorous diet at the age of 5 weeks (Banko 1960, Hansen et al.

1971). Their wide distribution necessitates an overall broad diet; however, within specific locations swans may forage selectively (Mitchell 1994). In Alaska, submerged aquatic plants are the primary food source before and during egg-laying until horsetail (*Equisetum* spp.) and sedge (*Carex lyngybie*), favored emergent plants, become available (Hansen et al. 1971). In contrast, swans in the tri-state area, just outside of USFS Region 2, feed predominately on submerged macrophytes, such as duck potato (*Potamogeton* spp.) and water weeds (*Elodea* spp.) (Banko 1960, Gale et al. 1987). Squires and Anderson (1995) examined swan diet in the tri-state region over the winter, spring, and summer and found dominant foods included: *Potamogeton* spp. (32.3 percent), *Chara* spp. (21.7 percent), *P. pectinatus* tubers (15.7 percent), and *Elodea canadensis* (11.4 percent). Food habitat data are lacking for Interior population flocks.

Breeding biology

Phenology

The start of the trumpeter swan breeding season usually begins in late April when breeding pairs begin nest-building. Nest-building is often initiated several weeks before the ice has melted from breeding ponds (Gale et al. 1987). However, in cold, wet years, nesting may be delayed, because females are often in poor condition (Henson and Cooper 1993). Breeding pairs exhibit strong site fidelity to previous years nest-sites and will often refurbish the previous years nest, especially if the pair successfully fledged young (Banko 1960). Nest construction takes from 11 to 35 days (Hansen et al. 1971, Cooper 1979).

Nest sites

Most nests are built in or surrounded by water. Nest placement adjacent to water likely serves several functions: reducing predation by mammals, providing access to aquatic vegetation for foraging, and ensuring that water is nearby when cygnets fledge (Mitchell 1994). Swans often select muskrat or beaver houses, beaver dams, exposed hummocks, floating platforms, or small islands as a foundation for the nest site (Hansen et al. 1971, Mitchell 1994). Nests are large, up to 1.2 to 3.6 m in diameter, and they are constructed from emergent and submerged aquatic vegetation, and occasionally grasses and sedges (Mitchell 1994).

Clutch size, incubation, and parental care

Clutch size appears to be highly variable by year and area (Mitchell 1994). In the tri-state subpopulation, clutch size is usually four to six eggs (Gale et al. 1987); Banko (1960) found a mean clutch size of 5.1 (n = 74) over an intermittent span of 7 years in Montana. The female incubates the eggs the majority of the time, but the male will nest-sit while the female is off the nest to forage (Henson and Cooper 1992). When females take incubation recesses, males spend more time at the nest and are more alert (Henson and Cooper 1993). The incubation period varies from 32 to 37 days (Banko 1960, Hansen et al. 1971).

Cygnets maintain close association with parents after hatching. It is unclear how soon young are led to water after hatching, but chicks are likely brooded during the first 24 to 48 hours after hatching. Young may continue to be brooded at brief intervals during the evenings when it is cold or during inclement weather for several weeks (Hansen et al. 1971, Mitchell 1994). Young develop flight skills at around 100 days old, often making many short distance practice flights, and they appear to stay with their parents through the first winter (Banko 1960, Hansen et al. 1971).

Demography

Genetic issues

Using the most up to date molecular techniques (i.e., mitochondrial sequencing and nuclear microsatellite analyses), Oyler-McCance et al. (2006) resolved two important questions related to the management of trumpeter swans. First, they found significant differentiation in haplotypes between the Pacific Coast and Rocky Mountain populations, with the Yukon Territory best viewed as an area of overlap, supporting the current management designations loosely based on flyways. These results also support findings by Pelizza and Britten (2002), who found a significant difference between the two populations using isozyme analysis. Measures of genetic diversity were, however, similar between populations, indicating that the Pacific Coast population likely underwent a genetic bottleneck much like the Rocky Mountain population, which was nearly extirpated in the late 1800's. The second question that Oyler-McCance et al. (2006) resolved was whether the Tri-state and Canadian breeding

flocks in the Rocky Mountain population should be considered sub-flocks within one population or unique populations. Genetic variation did not differ between the two breeding flocks, indicating that interbreeding likely occurs between the flocks even though they breed in distinct geographic areas. Consequently, there is no reason to treat them as unique populations from a genetic standpoint (Oyler-McCance et al. 2006). Further, swans in the Tri-state flock do not appear to have reduced genetic variation or increased amounts of inbreeding compared to other flocks (Oyler-McCance 2006). Low genetic diversity has been hypothesized as a possible explanation for the reduced productivity observed in this flock and its inability to increase in size at a rate similar to other flocks.

Oyler-McCance (2006)also evaluated genetic variation and diversity within flocks of the Interior population, which were all established through translocation of Rocky Mountain and Pacific Coast individuals. Except for the High Plains flock, genetic diversity of Interior population flocks was similar to flocks from other populations. The High Plains flock had lower genetic diversity than other flocks. This fact, coupled with mitochondrial evidence that the entire flock consisted of a sole haplotype, suggests that future management efforts may need to consider strategies to increase diversity (Oyler-McCance 2006). The High Plains flock is completely derived from Rocky Mountain population individuals, indicating that no interbreeding has occurred with individuals from the Pacific Coast population or from other Interior population flocks derived from Pacific Coast birds. Remaining flocks in the Interior population are derived from a combination of Rocky Mountain and Pacific Coast population individuals (Oyler-McCance 2006), likely reflecting the multiple sources of birds used to establish these flocks.

Life history characteristics

Most trumpeter swans first breed between 4 and 7 years of age (Banko 1960, Gale et al. 1987) although pair bonds develop as early as 20 months of age. Pair bonds occur on the breeding grounds in late March to mid-May. Mated birds breed annually.

Very little information exists for annual reproductive success, as measured by the number of cygnets fledged per breeding female, and no information on lifetime reproductive success exists. The data that are available suggest that annual reproduction is highly variable among flocks (**Table 2**) and years (Mitchell 1994). Studies of age- and time-specific survival are also lacking. Limited banding data have provided a broad range of survival estimates that are best viewed as averages, as survival likely varies greatly by age, year, and location (Mitchell 1994). The annual survival rate of 1 and 2 year-olds is estimated to be from 40 to 100 percent (Turner and Mackay 1981, Lockman 1990), while survival of individuals >2 years old is estimated to be slightly higher (80 to 100 percent)(Anderson et al. 1986, Bart et al. 1991). The oldest trumpeter swan captured in the wild was over 24 years of age, and swans in captivity have lived to 33 years of age (Mitchell 1994).

Due to the absence of data on reproduction and survivorship, and due to variable migratory patterns and habitat use among flocks, we have chosen not to perform a demographic analysis for this species. Although in some cases demographic analyses can illuminate critical aspects of a species' population biology and viability, the creation of models with incomplete data can equally result in irrelevant or misleading results (Reed et al. 2002). Given the variability of swan life history characteristics, behavioral patterns, and habitat use among flocks, future construction of these models may be most appropriate on a flock basis (Mitchell 1994).

Factors limiting population growth

There is little empirical information on the factors that limit population growth in trumpeter swans. The most commonly cited factor thought to limit population

Table 2. Summary of fecundity for trumpeter swans from sites in U.S. breeding segment of the Rocky Mountain population (Data from sources in Mitchell 1994).

		Number of young per breeding female	
Location	**N**	**Range**	**Mean (SD)**
Malheur National Wildlife Refuge, OR	18	0 – 3.09	1.36 (0.76)
Ruby Lake National Wildlife Refuge, NV	11	0 –1.2	0.59 (0.36)
Turnbull National Wildlife Refuge, WA	47	0 – 4.0	1.50 (1.20)
Red Rocks Lake National Wildlife Refuge, MT	34	0.12 – 2.82	0.96 (0.76)

growth in all three regional populations is the availability and quality of winter habitat (Gillette and Shea 1995, ADCIPTS 1998, Pacific Coast Flyway Committee 1998). However, as most swan flocks have experienced substantial population increases and all three regional populations have exhibited increasing population trends over the last quarter century, this perception may be a consequence of looking towards the future, when existing habitat becomes saturated, as opposed to current conditions. Concern over wintering habitat is driven by the significant loss of wetlands across the United States (Dahl 1990) and the fact that these losses have been the greatest in states below 40 degree latitude where climate factors keep most wetlands ice-free even during severe winters. In addition, many remaining wetlands believed to lie within the historic nonbreeding range of swans are unsuitable due to high lead levels. However, the concern over wintering habitat may be mitigated by the trumpeter's apparent plasticity in their selection of winter habitats. For example, wintering swans along the Washington and British Columbia coast have adapted to the loss of estuarine wetlands by using agricultural habitats.

Community ecology

Predators and competitors

Quantification of predation effects is lacking for trumpeter swans; however, given their large size, breeding swans may be able to effectively defend against many nest predators. A number of avian and mammalian nest predators have been reported to take eggs: common raven (*Corvus corax*), raccoon (*Procyon lotor*), wolverine (*Gulo luscus*), black and brown bear (*Ursus* spp.), and coyote and gray wolf (*Canis* spp.). Predation on older cygnets and adults is probably limited to large and quick predators such as golden eagle (*Aquila chrysaetos*), bobcat (*Lynx rufus*), red fox (*Vulpes vulpes*), and coyote (*Canis latrans*) (Mitchell 1994).

There is no information on interspecific competition related to trumpeter swans. Trumpeters are often observed foraging with other species of waterbirds, including Canada goose (*Branta canadensis*), mallard (*Anas platyrhnchos*), northern pintail (*A. acuta*), common and Barrow's goldeneye (*Bucephela* sp.), and American coot (*Fulica americana*) (Mitchell 1994). There is a perception by many waterfowl biologists that winter food is limited and, therefore, trumpeters may compete with other harvest-managed waterfowl; however, empirical evidence is lacking (Gillette and Linck 2004).

Parasites and diseases

Trumpeter swans are susceptible to numerous avian parasites and diseases. While flock or population level effects have not been reported, there is some concern that flocks may be vulnerable to epizootic outbreaks on the wintering grounds where overcrowding occurs, most notably in the tri-state region where both the Canadian and United States segments of the population winter (Shea 2004). In particular, the protozoan *Histomonas* has been listed as a species of concern due to its virulence and apparent specificity to trumpeter swans (Pacific Flyway Study Committee 1998). In 1991, there was a die-off of trumpeter swans at Fish Springs NWR, Utah attributed to systematic infection by *Histomonas*. Twenty-eight of 36 individuals died while other waterfowl species appeared to be unaffected (Shea and Drewian. 1999). Verified cases of avian cholera (*Pateurella mutocida*), avian tuberculosis (*Mycobacterium avium*), aspergillosis (*Aspergillosis* sp.), and avian pox have been detected in individuals (Mitchell 1994). Many parasites have been identified including coccidosis (*Eimeria* sp.), hematozoans (*Haemoproteus nettionis*, *Leucocytozoan simondi*), platyhelminths (*Notocotylus* sp.), nematodes (*Amidostomum anseris*, *Eurycera* sp.), trematodes (*Zygocotyle lunatum*, *Echinostomum revolutum*), cestodes (*Diorchis* sp., *Sapolevicanthus* sp.), and leeches (*Theromyzon* sp.) (Mitchell 1994). In the tri-state region, 27 percent of swan deaths during the winters of 2000 – 2003 in which cause of death was determined (n = 49) were attributed to diseases, parasites, and emaciation (Whitman and Mitchell 2004). Leeches were found on 12 percent of winter-caught swans, and infestations were lowest on adults, females, and heavier birds (Drewien and Bouffard 1994).

Envirogram

Figure 9 is an envirogram for the trumpeter swan. It represents the ecological relationships between trumpeter swan demographics, its habitat requirements, and its predators and competitors. The environment consists of the "centrum" and the "web". Only those things that are the proximate causes of changes in the physiology or behavior of the animal are placed in the "centrum". These are recognized as directly-acting components of the environment. Everything else acts indirectly, through an intermediary or a chain of intermediaries that ultimately influences the components in the "centrum". The linkages should be viewed as a series of hypotheses based on the ecology of trumpeter swans that land managers can consider

when evaluating management options (Andrewartha and Birch 1984).

CONSERVATION

Threats

Trumpeter swan populations have exhibited dramatic fluctuations over the last two centuries, mostly in response to human activities. Historical records from fossil remains and observational accounts prior to the early 1800's indicate that trumpeter swans were abundant and widespread across North America, with swans inhabiting a wide array of shallow, open, wetland habitats (Banko 1960). However, as trumpeter swan skins, feathers, and meat became important articles of frontier commerce, they were victimized by unrestrained market hunting, and populations declined steadily through the 1800's. Thought to be nearly extinct in the early 20th century, trumpeter swan populations have increased dramatically in the past century in response to protection from hunting, acquisition of lands specifically for trumpeter swans, and active management, most notably reintroductions. The re-establishment of trumpeter swans to many of their historical haunts has been accomplished through dedicated conservation efforts by partnerships of government agencies, private organizations, and concerned citizens, and can legitimately be labeled a classic conservation success (Gale et. al 1987). Indeed, each of the three regional populations is at its highest level in recent history, collectively approaching 35,000 individuals (Moser 2006).

Nonetheless, the trumpeter swan, including those flocks within and adjacent to USFS Region 2, still faces numerous threats. Understanding the significance of these threats at the population level, however, is difficult for several reasons. First, many of the threats are a result of recent range expansions and population size increases; thus numerical and behavioral responses by swans to specific threats are unclear. Secondly, information on the effects of land management practices on swan populations is lacking. Current management strategies are mostly restricted to the local scale, a byproduct of discrete flocks that have a unique restoration history and variable patterns of habitat use and migratory behavior; thus it is unclear if results are applicable at larger scales. Finally, the lack of information on trumpeter swan demographics limits our ability to directly assess threats in terms of population viability. Consequently, we focus our discussion of threats to effects on individuals, local flocks, and habitat quality and availability; where appropriate, we discuss population effects.

Wintering habitat

The biggest threats to trumpeter swans are issues related to the availability and quality of wintering habitat although individual threats differ slightly among the three regional populations (Gillette and Shea 1995). In the Pacific Coast population, the loss of agricultural habitats favored by swans, such as dairy farms and commercial crops (e.g., forage, grains, vegetables), to urban development and crops that swans avoid (e.g., berries, cottonwood plantations, tulips) are the primary threat to future generations of trumpeter swans (Subcommittee on Pacific Coast Trumpeter Swans 1993, Anderson 2004). Prior to Euro-American settlement, swans wintered in the extensive coastal estuaries and wetlands from southeast Alaska to California. These habitats were drained and diked for agricultural purposes in the late 1800's and early 1900's (Dahl 1990), after swans were nearly extirpated from the region. Over the last 30 years, the ability of Pacific Coast trumpeter swans to adapt to agricultural habitats is a major factor in the rapid increase of their population (Anderson 2004). Without efforts to maintain favored agricultural lands or restore estuarine wetlands, population levels may decrease.

The principal threat to the Rocky Mountain population of trumpeter swans also occurs on wintering habitat in the tri-state area of Wyoming, Montana, and Idaho, adjacent to Region 2. There, overcrowding on limited habitat by wintering Canadian swans and resident United States swans creates conditions where a substantial mortality event is possible if a severe freeze were to occur. Such an event would displace birds from feeding sites and increase the likelihood of mortality due to starvation or disease, with potentially significant consequences for the small United States breeding segment. Although the Rocky Mountain population has increased from 811 to 5,228 individuals from 1968 to 2005, this increase is almost entirely due to growth of the Canadian breeding segment; the Tri-state breeding segment of swans has fluctuated moderately in response to annual variation in recruitment, but it typically numbers around 400 individuals (Moser 2006). Further population increases by United States breeding flocks could be hindered by Canadian swans, which appear to have a competitive advantage over resident swans. Migratory Canadian swans have access to more diverse migratory stopover habitats, higher quality and more abundant breeding habitat, and greater flexibility to move within the wintering grounds (Shea 2004).

WEB 4	WEB 3	WEB 2	WEB 1	RESOURCES CENTRUM
			weather	food availability
		population expansion	overcrowding	food availability
		humans	pollution (lead)	nesting and foraging habitat
		wetland habitat	drainage/agriculture	nesting and foraging habitat

Figure 9a. Resources centrum for the trumpeter swan envirogram.

WEB 4	WEB 3	WEB 2	WEB 1	MALENTITIES CENTRUM
		humans	hunting	survival
		humans	power lines	survival
	humans	hunting	lead consumption	survival
Humans	feeding	lack of migration	weather	survival
			weather	fecundity
	lack of migration	overcrowding	disease	survival
	lack of migration	overcrowding	food availability	fecundity; survival

Figure 9b. Malentities centrum of the trumpeter swan envirogram.

Overcrowding is likely a result of two issues. First, swans have a strong site fidelity to wintering habitats; thus both population segments have continued to use the tri-state area as their primary wintering area even as habitat becomes increasingly limited. Secondly, swans were fed over a long period in the tri-state region, which likely contributed to sedentary behavior and dissuaded swans from making dispersal movements and developing migration pathways. Although feeding was discontinued in 1992, the development of migration patterns may take time, especially for such a long-lived bird. Recent efforts to establish migratory behavior have been mostly ineffective due to several factors, including tundra swan hunts in Utah (Shea 2004). Still, the number of documented dispersal movements has increased, particularly by Canadian birds. Additional

management may be needed to modify migration patterns (Interior Canada breeding segment) and to establish migratory traditions (United States breeding segment), as swans wintering in this area remain at risk of a severe mortality event.

The lack of natural migration patterns to suitable wintering areas represents the primary threat to trumpeter swan flocks in the Interior population, including the High Plains flock in Region 2. The Interior population has been created solely through reintroduction programs, primarily within the last two decades. These programs have been enormously successful as indicated by current population levels, which have significantly exceeded population objectives stated in the Interior Swan management plan (ADCIPTS 1998). However, another primary objective of the management plan, "to restore a migratory meta-population of trumpeter swans" (ADCIPTS 1998), has not been achieved.

Historical records suggest that most swans of the Interior population migrated to south of 40 degree latitude. Migration probably evolved in swans because habitat and climatic patterns dictated this response for long-term survival; swans wintering too far north were at risk of winter mortality due to severe freezes that made habitat and food inaccessible. Today, only 10 percent of the Interior population exhibits migratory behavior, and many flocks remain on wintering grounds where they either must be fed or remain vulnerable to severe winters. In Region 2, many individuals of the High Plains flock exhibit short distance migration, but most still winter north of 40 degrees. Many other flocks (e.g., Minnesota, Ontario) in the Interior population are supported through artificial feeding programs as existing local habitat does not meet foraging requirements. While providing supplemental food to trumpeter swans has resulted in increasing population sizes through increased winter survival, this management application has encouraged sedentary behavior, exacerbated overcrowding at feeding grounds, and reduced the need for migratory behavior. Without continued intensive management (i.e., feeding), these flocks are at risk of severe mortality events.

Establishing migratory traditions in the Interior population appears to be feasible, but it takes time, and the most effective technique (supplemental feeding) is controversial (Gillette and Linck 2004). Trumpeters will return to a wintering site if they find it attractive, and supplemental feeding in several southern locations has attracted small groups of swans. Because swans migrate as family units, and not as flocks like most waterfowl, migration pathways are slow to develop. However, as individual family groups locate suitable wintering areas, they will attract other swans and, over time, effectively establish a wintering area.

The development of migration behavior, however, requires suitable wintering areas of sufficient size and quality to support significant numbers of swans. Although no formal study to identify wintering sites has been conducted, evidence suggests that appropriate wintering sites may be limiting. While supplemental feeding can initially attract swans, sites need to have sufficient food resources that swans can discover and adapt to, such as natural wetlands or agricultural fields with waste grain. Although agricultural habitats may be available as wintering sites, apparently few suitable wetlands remain. Wetland loss in the Midwest and eastern United States was extensive through the 1900's, with many states losing greater than 70 percent of their wetlands to agriculture and development (Dahl 1990). Many of the remaining wetlands that could serve as wintering sites are not suitable because they are historic hunting grounds significant levels of highly toxic lead shot (see Lead poisoning). Some open water habitats have been created by dams, power plants, stock ponds, reservoirs, and other water development, but it is unclear if these sites provide suitable foraging habitat for swans or other waterfowl (ADCIPTS 1998). A second factor limiting available wintering habitat is the fact that many southern states to which swans could migrate are unenthusiastic about swans wintering in areas traditionally managed for waterfowl and harvest-driven population objectives (Gillette and Linck 2004). This lack of cooperation between northern states, which manage breeding populations, and southern states, which offer wintering habitat opportunities, hampers the creation of a management effort based on the ecology of the trumpeter swan. Southern states are concerned about implementing swan management activities because (1) managers believe swans may compete with hunted waterfowl for limited resources, and (2) the presence of swans may increase the likelihood of accidental killing of swans and thus bring unwanted controversy to the hunting community (Gillette and Linck 2004).

Lead poisoning

Lead poisoning is a significant threat to trumpeter swans both directly as a leading cause of mortality and indirectly by reducing habitat management opportunities in high quality wetlands with a long-term hunting legacy. The use of lead shot for hunting waterfowl was banned in 1991 and 1999 in the United States and

Canada, respectively. However, lead shot remains legal for most other forms of hunting in uplands and target shooting activities (trap and skeet), and lead jigs and sinkers remain legal for fishing. Swans are vulnerable to lead poisoning because they grub on the floor of wetlands and lakes for grit and aquatic vegetation, increasing the likelihood of uncovering legacy lead shot, and because much of their diet requires thorough grinding in the gizzard, which increases the rate of lead absorption (Gillette 1990). Incidences of lead poisoning occur in areas that have not been hunted for more than 30 years, and only three or four pieces of lead shot need be ingested to cause mortality (Wilson et al. 2004).

Lead poisoning is a significant mortality factor in all three regional populations. It has been particularly problematic to swans on Pacific Coast population wintering grounds in Washington and British Columbia, where over 1,800 trumpeter swans have died from acute lead toxicity over a six-year period (1999-2005; Washington Swan Working Group 2005). In addition to direct mortality, sublethal levels of lead were detected in approximately 30 percent of the trumpeter swans in this area (Washington Swan Working Group 2005). The effects of chronic, sublethal levels of lead to waterfowl are significant and include increased susceptibility to disease and infection, increased predation due to anemia and weakened muscles, lower survival during migration, and lowered productivity (Sanderson and Bellrose 1986). Prior to 1999, only one other die-off was recorded in Washington (in 1992), indicating that areas can be safe for significant periods of time and then become serious hazards. Lead poisoning is also a major issue in the Interior and Rocky Mountain populations, accounting for 23 and 16 percent of all known mortality, respectively (ADCIPTS 2002, Whitman and Mitchell 2004).

The impacts of lead poisoning are equally significant as an indirect threat to swans because they can force management activities for swans away from otherwise high-quality wetlands that have a long legacy of waterfowl hunting and toward potentially lower-quality wetlands that are lead free. Consequently, because management must focus on lead-free sites, some available habitat will be not used. Concerns have been raised as to whether enough lead-free habitats remain to support increasing numbers of trumpeter swans of the Interior population (ADCIPTS 1998). Considering that there is currently no effective way to remove lead from wetlands, swan management efforts will be dealing with issues related to lead poisoning for many years. Monitoring and tracking swan movements in areas where high mortality occurs will be needed to locate aquatic sites contaminated with lead.

Hunting

The dramatic reduction of trumpeter swans in the 1800's was clearly a result of commercial hunting pressure. Although the Migratory Bird Treaty Act of 1918 outlawed the legal take of trumpeter swans, they continue to be killed either maliciously or mistakenly because of their similar appearance to tundra swans and snow geese (McKelvey and MacNeill 1981, Gale et al. 1987, Blus et al. 1989). Consequently, hunting remains a threat to trumpeter swans. It is unclear the degree to which malicious killings of trumpeter swans occurs, as many individuals are unlikely to be discovered. In the Interior population, 26 percent (122 of 476) of known swan mortality from 1976 – 1999 was due to shooting (ADCIPTS 2002). In South Dakota and other states adjacent to USFS Region 2 (i.e., North Dakota, Montana, Utah), tundra swans are still hunted, and in Nebraska, Colorado, and other central latitude and southern states, snow goose hunts are permitted. Records from the Central flyway found no conflict between tundra swan hunts and trumpeter swan restoration, but as trumpeter populations increase the likelihood of some take will increase (Vaa et al. 1997). Perhaps the biggest conflict created by tundra swan hunting occurs in the Bear River Delta in Utah, where it has precluded reintroduction attempts that are aimed at developing a southward migration pathway for tri-state area trumpeter swans. Hunting also may reduce the likelihood of colonization by naturally dispersing trumpeter swans into that region due to increased mortality (Shea 2004). Efforts to mitigate losses of trumpeter swans have included shortening the tundra swan hunting season, reducing the geographic area, and implementing a harvest quota on tundra swans (Trost et al. 2000). There is no information as to whether these actions have been effective, and this issue remains controversial (Shea 2004).

Power lines

Collisions with power lines and other human-built structures such as wire fences appear to be a significant source of mortality, but it is unclear if they have a population or flock-level effect. Collisions were the cause of death in 62 percent of deceased birds (*n* = 13) found in Wyoming from 1980-1986 (Lockman 1990). Collisions with power lines make up 16 percent of known mortalities in the Interior population and may be underrepresented due to the difficulty of locating dead individuals (ADCIPTS 2002). Power

lines are especially problematic where they cross wetlands, rivers, or other migration routes used by swans. However, recent management techniques such as burying power lines and installing devices on power lines known as swan flight diverters in areas where conflicts occur are effective in minimizing this threat (Mitchell 1994).

Recreation and scientific activities

Recreational activities, both motorized and non-motorized, can reduce habitat availability and quality for trumpeter swans in breeding and non-breeding areas, and thus they are considered significant threats. Due to swan sensitivity to human disturbance, wetlands otherwise suitable for trumpeter swan but subject to disturbance by human activity, are likely to be avoided by swans, reducing overall habitat availability. Loud noise from motorized recreational activities, such as boats, all-terrain vehicles, float planes, and motorcycles, can disturb nesting swans (Page 1976, Gale et al. 1987, Henson and Grant 1991). If breeding areas are intruded on frequently, swans may abandon their nest and eggs (Mitchell 1994). Motorized disturbances, if sustained and excessively loud, can also alter swan behavior, particularly of females, leading to increased probability of nest predation, egg mortality, delayed development of exposed eggs, or insufficient care to cygnets. Henson and Grant (1991) found that undisturbed females always covered eggs prior to leaving the nest, took shorter recesses from the nest, and spent more time feeding and preening while away from the nest compared to disturbed females who failed to cover eggs 26 of 28 times they recessed from the nest. A frequent cause of disturbance occurs when vehicles stop along roadsides or honk their horns; however, vehicle traffic alone is probably not a serious problem in most locations (Henson and Grant 1991). As with vehicle traffic, trumpeter swans become alerted by over-flying aircraft; however, disturbance appears minimal as changes in incubation behavior by females or cygnet behavior have not been detected (Henson and Grant 1991).

Non-motorized human activities, such as bird watching, photography, and other activities by pedestrians or researchers, elicit the greatest response by swans during the breeding season (Henson and Grant 1991). Pedestrians cause disturbance to trumpeter swans by disrupting adults, causing short- or long-term nest abandonment, and resulting in displacement from breeding areas (Banko 1960, Hensen et al. 1971, Page 1976, Shea 1979, Bangs et al. 1982, Henson and Grant 1991). Pedestrians or researchers can also influence incubation and brood rearing behavior and contribute to nest failure or death of cygnets (Holton 1982, Gale et al. 1987, Henson and Grant 1991). Although visual barriers such as vegetation and hills situated between sources of disturbance and nesting swans may serve to decrease the impact of disturbances, swans are known to respond to noises made by humans even when they were not visible (Henson and Grant 1991). Henson and Grant (1991) recommend that wildlife viewing areas should be concealed in vegetation, designed to minimize noise of users, and located at a distance greater than 300 m from swan nests.

There is little information about the effects of human activities to swans on wintering grounds. However, those human activities that disturb swans on breeding grounds likely affect swan behavior on wintering grounds. Disturbances to swans that disrupt winter foraging activities or cause frequent movements from resting areas may decrease overall condition or even cause mortality. Swans in poorer condition on the wintering grounds may have higher mortality during a severe winter event or epizootic outbreaks.

Conservation Status of the Trumpeter Swan in Region 2

Trumpeter swans were likely extirpated from the area now encompassed by USFS Region 2 sometime in the early 1900's. Natural history accounts of wildlife did not feature prominently in the scientific literature until the late 1800's, with the beginning of a conservation ethic in the United States. Thus, our knowledge of the historic abundance and distribution of swans is generated from sporadic historical accounts and assumptions based on our current knowledge of swans and their habitat needs. As a consequence, there is significant uncertainty regarding their historical abundance and distribution in Region 2. The best information comes from a thorough review of historical records by Banko (1960). In this document, he suggests that habitats in the Great Plains region did not support a significant breeding portion of the trumpeter swan continental population. However, this qualitative assessment provides no numerical population or habitat estimates that could serve as conservation targets for either breeding or wintering swans.

The High Plains flock is the only flock that occurs in Region 2 and is a component of the Interior population. This flock is descended from Tri-state flock swans of the Rocky Mountain population, which were translocated to Lacreek NWR, South Dakota from 1960-1962 (Monnie 1966). The High Plains flock has increased substantially from the original 57 cygnets

released in Lacreek NWR to 534 individuals in 2004 (ADCIPTS 2004). As the founding population increased, the distribution of breeding swans has expanded, with swans pioneering suitable habitat in South Dakota, Wyoming, and Nebraska, and developing a migratory subflock that breeds in Saskatchewan. The wintering population distribution has also expanded from its original wintering area in Lacreek NWR to many areas of the Nebraska Sandhills, and it may be developing migratory patterns to states farther south (Kraft 2004). In 2004, the High Plains flock reached its population objective of 500 individuals, as defined in the Interior population management plan (ADCIPTS 1998), and evidence suggests that this flock is self-sustaining (Kraft 2004). The impressive population growth rate is not limited to the High Plains flock; the entire Interior population has experienced an annual growth rate of 11.7 percent from 1968 – 2005 (Moser 2006) and reached its population target of 2,000 individuals in 1999 (ADCIPTS 2002). Since then, population size has continued to increase rapidly, approaching 5,000 individuals in 2005 (Moser 2006).

The extent to which trumpeter swan numbers can continue to increase in Region 2 is unclear, and this makes it difficult to determine the swan's conservation status. To date, there has not been a published assessment detailing the amount of unoccupied and suitable wetland habitat remaining in Region 2 for either breeding or overwintering swans; nor do we understand the landscape-scale characteristics required to support an expanding trumpeter swan flock (see Information Needs section). In addition, if the number of swans were to increase in the High Plains flock, an increasing portion would likely reside within Region 2 only on a seasonal basis. Thus, their status will also be influenced by the political will of, and subsequent management by, federal, state, provincial, and local agencies outside of Region 2.

The loss of over 41 percent of wetlands within the states of Region 2 after Euro-American settlement (Dahl 1990) undoubtedly hampers the ability of swans to recolonize portions of their historic breeding range. Trumpeter swans require specific habitat elements for breeding:

- shallow wetlands (< 1.5 m) containing submerged aquatic vegetation
- minimal hunting history (i.e., lead contamination)
- little human disturbance.

As long as these elements are in place, there is little evidence that habitat quality varies substantially. Like many areas in North America, the rate of wetland loss in Region 2 has slowed considerably due to increased federal protection and awareness of the importance of wetland ecosystems. Moreover, there are an increasing number of opportunities to both restore and create wetland habitat suitable for trumpeter swans through innovative conservation funding programs, such as the Wetland Reserve Program, the USFWS Joint Venture Program, and North American Wetlands Conservation Act grants. Outside of Region 2, suitable nesting habitat remains abundant and underutilized across the northern United States and southern Canada (ADCIPTS 1998). Thus, at the very least, the High Plains flock has the potential to increase through population growth in the Canadian breeding segment in eastern Saskatchewan.

Trumpeter swans in Region 2 may be most vulnerable on their wintering grounds because the majority of individuals reside in areas north of 40 degrees latitude, where they risk increased mortality from severe weather events. Moreover, if populations expand, the availability of already limited wintering habitat will decline further, and overcrowding may become an issue. Winter overcrowding in the tri-state area is considered a significant problem in the Rocky Mountain population, and is believed to result in increased mortality due to the interaction between weather, depleted food resources, and disease. Trumpeter swans occupy a broader array of habitats during the winter than the breeding season, as long as open, lead-free waters with aquatic vegetation or nearby agricultural fields containing excess grains or vegetable crops are present. Although natural wetlands have been lost, new open-water wintering habitat created through the building of dams, power plant, stock ponds, reservoirs, or other water development projects has increased, and this may offer suitable habitat or opportunities to manage habitat.

The development of migratory behavior to unoccupied wintering habitat farther south could ameliorate problems associated with limited winter habitat and overcrowding; however, to date migratory behavior by swans breeding in Region 2 is limited. Unfortunately, there is a significant lack of information on dispersal and the development of migratory behavior by swans, partly because of the relatively young population history of these flocks. The lack of migration observed in the Tri-state flock and its resulting negative consequences may be due in part to long-term winter feeding that occurred into the early 1990's, which instilled sedentary behavior; winter feeding also

occurred in Lacreek NWR until 1992. An increased number of observations of swans in states south of their current breeding locations in Region 2 and in other parts of their range indicate that some migratory behavior may be developing.

Overall, the likelihood of the trumpeter swan becoming extirpated in Region 2 is low, especially given the degree of management afforded this species. In addition to federal agencies, swans are supported by many state and provincial agencies, an active public, and a proactive conservation group, The Trumpeter Swan Society. Regardless, swans may deserve recognition as a species of concern within Region 2 due to the small size of the High Plains flock. Still, optimism appears warranted regarding the future of trumpeter swans in Region 2 since the High Plains flock has reached its population target as defined by the Interior population management plan, its numbers are trending upward, and the overall Interior population continues to increase.

Potential Management of the Trumpeter Swan in Region 2

Implications and potential conservation elements

The trumpeter swan has recovered from its low population numbers in the early 1900's through a variety of conservation actions including protection from hunting, public education, reintroductions, and land acquisitions (particularly for inclusion into the network of USFWS National Wildlife Refuges). Today, the trumpeter swan is one of the most highly managed bird species in North America. Although overarching management objectives are directed by a national waterfowl management plan and three regional trumpeter swan management plans, specific management actions are carried by federal, state, and provincial agencies and public and private conservation organizations, either individually or through loose partnerships. The trumpeter swan is a large, highly visible, and charismatic bird species that attracts a significant amount of support from the general public, providing both additional resources and mechanisms to develop and implement management actions. Most on-the-ground management, however, is performed on a flock by flock basis, as individual flocks are patchily distributed across the landscape as discrete units and have unique habitat use and migratory patterns (Mitchell 1994).

The increasing number of trumpeter swans using habitats in Region 2 during the breeding and nonbreeding seasons indicates that existing landscape conditions and management actions have been favorable for this species. Indeed, the species has reached its population target, as identified in the Interior population management plan. However, the extent to which swan numbers can increase beyond existing population objectives and expand their distribution across a larger portion of their historical range is uncertain for at least two reasons: (1) the amount of unoccupied and suitable habitat that is currently available for trumpeter swans is unknown, and (2) information on the effects of management on trumpeter swans is lacking. Consequently, many conservation elements for the High Plains flock and other flocks in the Interior population are conceptual, and specific strategies are still being debated. With the recent dramatic increases in population size, much of this information should become more available.

If the management objective is to increase the size and expand the range of the High Plains flock in Region 2 beyond the existing population target, the quantity and quality of wetland habitats for breeding, migration, and overwintering will need to be increased. This will primarily be accomplished through management that emphasizes protecting, restoring, and creating suitable wetland habitats. The outcome of such actions should not only improve conditions for swans, but also a suite of other wetland dependent species.

Management approaches that are specifically directed towards providing wintering habitat and increasing migration behavior are likely to have the greatest benefits for swans. Within Region 2, only Kansas and Colorado are positioned south of the 40 degree latitude line, which is the targeted location for trumpeter swan wintering areas (ADCIPTS 2002). However, only Kansas appears to have the wetland resources that could serve as wintering habitat; Colorado offers few apparent management opportunities (**Figure 5**; ADCIPTS 2002). Management should be focused on areas where swans have been previously observed or areas that appear suitable to swans (ADCIPTS 2002). Important questions that need to be considered when identifying sites for management include:

- is the site free of lead?
- is it a prime hunting site
- are food resources adequate, either containing natural aquatic vegetation or other food sources, such as favored agricultural crops (e.g., potatoes, carrots)?

The need to re-establish migratory behavior is becoming an important management goal because an increasing proportion of swans in Region 2 remain susceptible to severe winter freezes. In addition, without the emergence of migration behavior, current wintering areas may become increasingly overcrowded, resulting in many of the same problems that are plaguing the swan flocks wintering in the tri-state region of the Rocky Mountain population. Currently, migratory behavior by flocks of the Interior population is limited, with few individuals moving south of 40 degrees latitude. Individuals of the High Plains flock exhibit the most movement; however, these are mostly restricted to short distance movements, and many birds still winter in habitats that may experience significant freezes (Gillette and Linck 2004).

The development of southward migration will be a slow process for several reasons. First, swans of the High Plains flock were fed at Lacreek NWR until 1992. Although this contributed to population growth, it also encouraged sedentary behavior, which may take time to alter. Secondly, swans exhibit strong philopatric behavior to wintering sites; thus only a small number of individuals may initiate migratory behavior. Those swans that initiate migration have higher mortality rates than nonmigratory individuals because of increased probability of exposure to lead poisoning, hunting, or power line collisions. However, once swans locate suitable wintering sites, migration will likely occur directly to and from these sites, and mortality will be reduced. Further development may occur in a stepwise fashion as small winter flocks become established.

Opportunities to expand the breeding range of swans in Region 2 may exist, and might contribute to the population's long-term viability. Based on preliminary GAP analysis (**Figure 4**), wetlands in central and eastern Wyoming appear capable of supporting breeding swans. Identifying appropriate areas for management would require locating suitable wetlands where water levels will not fluctuate during the nesting season, that are free of lead, and that have sufficient quantities of submerged vegetation and limited human disturbance. Establishing breeding flocks in Wyoming might create a linkage between the High Plains flock in Region 2 and the Tri-state breeding flock just outside of Region 2. Such a linkage may be beneficial to the long term viability of both flocks. In addition, this management would appear to be appropriate at a population level, given that these flocks are genetically identical. Specific locations where the USFS could contribute to this effort should be evaluated. Any effort to expand the breeding distribution of swans in Region 2 should be paired with efforts to provide wintering habitat either inside Region 2 or farther south.

Although management efforts may be most easily conducted on public lands, strong consideration must be given to focusing efforts on private lands, as over 70 percent of lands within the Great Plains are private. By far, the greatest loss of wetland habitat has been due to the conversion to croplands. Thus, there are significant opportunities to develop partnerships among landowners and state and federal agencies aimed at the restoration and conservation of wetland habitat and the species that depend upon them. Many conservation organizations, such as the Trumpeter Swan Society, Wyoming Wetlands Society, and Ducks Unlimited, are working to protect, restore, and create wetland habitat through federal programs such as The Wetland Reserve Program and The North American Wetland Conservation Act. Moreover, many of these organizations also focus on public education, which is ultimately the cornerstone of any successful conservation action. The Trumpeter Swan Society is perhaps the organization most dedicated to the conservation of trumpeter swans and their habitats, and it has been an influential leader in trumpeter swan restoration efforts throughout North America. This organization has promoted and improved management programs by focusing on population sustainability though breeding, wintering, and migratory range expansion and habitat protection. The reader is encouraged to review The Trumpeter Swan Society website (http://www.trumpeterswansociety.org/index.htm.), which contains quarterly newsletters describing the most pressing management issues for each regional swan population, proceedings from previous Trumpeter Swan Society Conferences, and a thorough description of the conservation programs they perform to aid in trumpeter swan conservation and recovery:

Tools and practices

Species inventory and monitoring

The trumpeter swan is one of the best-monitored species in North America. The USFWS and Canadian Wildlife Service oversee a range-wide census every five years on the breeding grounds, as directed by the three regional management plans. In addition, the majority of flocks in the United States, including the High Plains flock in Region 2, are annually censused during the late breeding season and during the winter. Swans are extremely conspicuous due to their large size, distinct coloration, and gregarious nature, making them an

easy target to identify and count using aerial or ground surveys. Although the ultimate goals of a species "inventory" and "monitoring" differ (Hunter 2000), the techniques for both of these approaches are identical for this species.

The cinquennial range-wide survey directed by the USFWS and Canadian Wildlife Service is conducted by federal and state biologists, private organizations, and volunteers, largely on a flock by flock basis. The preferred monitoring technique is aerial surveys because of their efficiency in covering the widespread and remote habitats that trumpeter swans occupy. Ground surveys are utilized in isolated pockets of habitat that are not covered by aerial surveys, such as the restoration flock in Oregon and Nevada and some Interior population flocks. Except for northern British Columbia and the Yukon Territory, surveys are believed to be complete censuses; in British Columbia and Yukon Territory, population estimates are based on stratified random samples across the suspected range of trumpeter swans (Moser 2006). This survey is conducted late in the breeding season, and the number of white birds (i.e., breeding pairs, mature nonbreeders, and subadults) and cygnets are counted. For example, in 2000 the median starting and ending date for surveys were 20 August and 11 September, respectively (Caithammer 2001). Breeders and nonbreeders cannot be separated from the air; consequently, the total number of white birds provides the best measure for population trends (Caithammer 2001). Recently, it has been noted that the trumpeter swan population has become too large and expansive in Alaska and Canada to financially justify continuing this survey (Anderson 2004). A survey design using a stratified random sampling protocol over the probable range of trumpeter swans would appear to be the best compromise between cost and adequately detecting range and population expansions.

In Region 2, the High Plains flock is also monitored annually during the late breeding season and during the winter, as are many other United States flocks. The late breeding season survey provides an estimate of the population size of the U.S. breeding segment and a coarse index of productivity (percentage of count that are cygnets), while the winter survey provides an estimate of the complete flock size, including United States and Canadian breeding birds. The High Plains flock is surveyed aerially within 200 miles of the Lacreek NWR. Currently, the survey area includes Bennett, Shannon, Pennington, Meade, Butte, Perkins, Ziebach, Haakon, Jackson, Mellette, Tripp, and Todd counties in South Dakota; Cherry, Sheridan, Garden, Grant, McPherson, Hooker, and Arthur counties in Nebraska, and Crook County in Wyoming (Kraft 2004). Outside the Lacreek survey area, additional data are obtained from ground sightings of federal, state, and county employees, and private citizens. During the breeding season count, this method of accumulating sightings to determine population numbers likely underestimates the numbers of subadult trumpeter swans, because subadults are more mobile than breeders with cygnets. Unless funding is procured to complete a more extensive aerial survey, estimates for the Interior population will likely be regarded as less accurate than more complete censuses conducted in the Rocky Mountain and Pacific Coast populations.

The accuracy of current survey methods may decrease further in Region 2 as swans expand their range outside the aerial survey region and as the percentage of marked swans decreases. As swans increase beyond their current range, there is an increased risk that they will be missed and, as a result, populations underestimated. Trumpeter swans travel in pairs and family units; thus identifying and recording of a band from one member of the group can verify sightings and reduce the likelihood of individual swans being recorded more than once (ADCIPTS 1998). Without additional funds to expand the aerial survey, the best alternative to reduce error in population estimates may be to increase banding efforts of wild-reared swans through capturing cygnets at nest sites, subadults on molting grounds, and/or family groups on wintering grounds (ADCIPTS 1998).

Overall, survey methods for flocks within each regional population vary slightly. Certainly, developing a more standardized survey protocol may reduce error and potential biases of the current surveys. Thus, it is not surprising that developing standardized protocols are noted in all three regional management plans as an important management objective. As the population continues to increase more issues will arise. For example, there will likely be confusion and, therefore, error resulting from misidentification of tundra and trumpeter swans as trumpeter swans pioneer habitats previously only used by tundra swans. Further research into developing an effective sampling method to estimate population size should be explored; if the population continues to increase, the current comprehensive monitoring effort becomes less warranted. A greater effort should be made to ensure that the general public, especially birding groups, are aware of the need to report trumpeter swan observations, especially observations of banded individuals. Agency biologists or private individuals who locate swans within Region 2 or who are interested in contributing to survey efforts conducted in Region

2 should contact the Trumpeter Swan Society (http://www.trumpeterswansociety.org), who can then direct individuals to the current chair of the swan committee for the Mississippi and Central Flyways.

Habitat inventory and monitoring

When possible, habitat inventory and monitoring efforts should be conducted concomitant to trumpeter swan monitoring. Understanding the relationships of trumpeter swan presence, population trends, and vital rates to habitat characteristics is important to determine causes of population changes and to identify and assess consequences of management activities and conservation strategies. Habitat characteristics should be measured at landscape and local (i.e., wetland) scales. As a first course of action, swan locations from aerial and ground surveys should be mapped for later landscape habitat analyses. Further, on-the-ground sampling of habitat attributes could be conducted after swans, which are easily disturbed, have left the area.

With the increasing availability and accuracy of geographic data, such as vegetation and hydrology, Geographic Information System (GIS) techniques offer tremendous potential to identify and monitor habitat for trumpeter swans. Based on the research conducted for this assessment, important landscape characteristics that should be considered in any evaluation of swan habitat include the quantity, type (e.g., depth, natural vs. manmade) and configuration of wetland habitats, the density of roads and power lines, and the matrix of habitats surrounding utilized wetlands. With this information, habitat-use models could be developed to identify currently unoccupied aquatic environments that may be suitable for trumpeter swans. Local habitat variables that should be measured include structural characteristics of vegetation in and surrounding wetlands, food availability, and aquatic species composition; other characteristics that may be important to trumpeter swans are described previously in the Habitat section. Data collection on surrounding vegetation, food availability, and distance to other habitat patches could be useful in understanding the nutritional requirements of trumpeter swans. Regular evaluation of lead levels should be a component of any habitat monitoring program developed for trumpeter swans.

Management approaches

The recovery of trumpeter swan populations from near extirpation in the early 1900's is considered one of the greatest success stories in wildlife management (Gillette and Shea 1995). Considerable management has been aimed specifically towards conservation of trumpeter swan populations and has included protection from hunting, reintroductions, and supplemental feeding programs.

Within Region 2, the most effective management actions will likely include efforts to encourage expansion of the existing breeding population to unoccupied areas through restoring or creating wetland habitat suitable for swans. Few opportunities exist for management of wintering habitat, as the majority of the Region 2 area lies above the 40 degree latitude line. Specific habitat management recommendations have not been developed for breeding swans in Region 2, but broad habitat requirements developed for swans of the Rocky Mountain Population (Pacific Flyway Study Committee 2004) can likely be applied to Region 2 habitats and should provide guidance for habitat management. Some of the primary habitat elements required for wetland restoration or management actions to benefit trumpeter swans include:

- a wetland surface that extends 100m in any direction
- highly irregular shorelines
- water levels with mean water depth less than 1.2 m
- pollutant free (especially lead) water
- no fences, power lines, or other flight obstructions.

For managed wetlands with water control structures, periodic drawdowns during the growing season are likely important to maintain habitat quality for nesting swans. Drawdowns should mimic the wet/dry cycles that would naturally expose wetland soils, promoting oxidation and the release of nutrients, thereby increasing wetland productivity upon re-flooding. Although this action may result in nesting habitat being unavailable during the drawdown year, the long-term wetland productivity for trumpeter swans can be increased (R. Shea, personal communication 2006). Unfortunately, information is lacking for the optimal frequency of a drawdown management strategy for swans, but a general rule of thumb may be every five to 15 years, depending on the site's climate, elevation, and soils.

Reintroduction programs have been the most important management tool in re-establishing breeding

populations of trumpeter swans in many areas of North America, including the High Plains Flock. Several methods have been utilized including release of captive-reared and wild cygnets and yearlings. While a number of reintroductions have proven successful, a review of the factors essential to a successful reintroduction is lacking, and specific guidelines for swan reintroductions have not been developed. All reintroduction programs should follow IUCN (1995) guidelines. Accordingly, in any reintroduction, the species' habitat requirements across the annual cycle must be considered. This appears to be lacking in many previous reintroductions in both the Interior and the Rocky Mountain populations, as releases are substantially biased towards northern breeding grounds that are poorly suited for wintering. One alternative is to conduct reintroduction efforts on suitable habitats in southerly locations that can support wintering swans, and allow subsequent generations to search north for nesting grounds. This appears to be the typical manner in which trumpeters pioneer new areas (Burgess et al. 1999) and is how the Saskatchewan subflock of the High Plain flock developed.

The use of winter supplemental feeding as a management tool has been, and remains, a controversial subject (Gillette and Linck 2004). Supplemental feeding was a component of restoration programs on USFWS refuges until 1992, when that policy was discontinued. Many of the swan flocks in the Interior population (e.g., Minnesota, Ontario) still winter near their breeding ground and are fed by private citizens or state or local government agencies since natural food sources are inadequate. Although some of the population growth observed in the Interior population has been attributed to supplemental feeding, it has also likely promoted sedentary behavior. Considering the overall objective of the existing Interior population management plan is to restore a self-sustaining, migratory population of swans, supplemental feeding on wintering areas would appear to be inappropriate. Supplemental feeding may be useful in developing migratory behavior, however, by using it as a technique to attract swans to suitable wintering areas. Once swans discover natural foods, supplemental feeding could be discontinued.

Information Needs

Through dedicated efforts by government agencies and private organizations and individuals, trumpeter swan populations have rebounded from near extinction. Yet, further research is necessary to improve management and conservation efforts aimed at restoring the trumpeter swan to its historical haunts across North America. In Region 2, one of the primary information needs is an assessment to determine the amount of unoccupied, yet suitable, habitat that is available for trumpeter swans. To obtain this information, more research will also be needed to understand the specific habitat requirements associated with breeding, migration, and overwintering sites at both landscape and local scales (ADCIPTS 2002). Standardized methodologies to quantify habitat and landscape characteristics should be established as soon as possible to ensure consistency across flocks and populations.

There is a significant need for studies that evaluate the effects of management on trumpeter swans (ADCIPTS 2002). This information should become increasingly available as swan populations are reaching levels where the effects of management can be properly assessed. For example, research on the most appropriate time to conduct wetland drawdowns would be extremely beneficial as most National Wildlife Refuges maintain wetlands with water control structures.

Research on trumpeter swans should be aimed at age- and sex-specific differences and between migratory and sedentary flocks, as most management must be addressed on a flock-by-flock basis due to differences in migratory behavior, habitat use, and demographics (Mitchell 1994). The initiation of long-term studies of marked individuals would provide avenues of research on many aspects of swan behavior and ecology, including comparisons among populations, comparisons of migratory versus resident life, relationships between reproduction and mate fidelity, and relationships between demographics and habitat quality (Mitchell 1994). With these types of data, biologists will be better equipped to understand and predict the effects of different management strategies and conservation actions on population trends and persistence of trumpeter swan flocks.

Questions related to habitat quality and nutrition of trumpeter swans would provide fruitful avenues of research (Mitchell 1994). A better understanding of the role of nutrition in cygnet growth and subsequent adult size, survivorship, mate fidelity, and annual and lifetime reproductive success, will improve our knowledge of the impacts of habitat degradation (Mitchell 1994). Studies of foraging ecology and nutritional needs comparing migratory and resident populations and swans foraging on agricultural crops versus natural food sources need to be conducted (Mitchell 1994).

Research is needed to better understand migration patterns for each population. Even though trumpeter swans appear to exhibit strong fidelity to migratory

stopover sites, timing and exact routes of fall and spring migration are not well quantified nor are data describing foraging habits during migration (Mitchell 1994). A more comprehensive knowledge of migratory behavior may also provide new and innovative insight into methods for re-establishing migratory tradition in sedentary flocks. Previously proposed methods such as decoy rearing should be examined for usefulness and feasibility. Innovative new ideas for restoring migratory tradition such as the use of ultralight guidance through pre-selected route and stage-by-stage methods could be examined to determine if these techniques offer feasible and successful alternatives to re-establishing migratory tradition in sedentary flocks (Sladen 2002).

Finally, the recent genetic study by Oyler-McCance et al. (2006) resolved several genetic issues related to the Pacific Coast and Rocky Mountain populations. However, some areas, including several flocks from the Interior population were not sampled. Analyses with samples from these flocks would provide a comprehensive picture of the distribution of genetic variation across the species' range, and would be beneficial for continued management efforts.

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